NOTES OF A CATHOLIC BIOLOGIST

BY

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"For by the greatness of the beauty, and of the creature, the Creator of them may be seen, so as to be known thereby."

—(Wisdom xiii, 5)

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PREFATORY NOTE

The topics discussed in the following pages are not wholly unfamiliar to those who have pursued a course of studies either at a University, College or High School. However, there is a larger, if less favored class of readers, whose restricted advantages have not permitted them to be informed on scientific subjects. Since lack of information could not be construed as want of interest, it was felt that there was a place, if not indeed a need for a work of this kind, which in an informal manner would serve to introduce such readers to scientific thought. Yet, this is but part of the purpose of the author. He feels that the facts of science should not be allowed to stand by themselves, isolated and alone. Ultimately such facts are not self-explanatory, but rather contain in themselves an appeal beyond. They aid us in making the step from Nature to the Author of Nature. There is excellent warrantry for believing that from the visible things of Creation, the mind may readily

ascend to a consideration of their Invisible Creator. But this somewhat anticipates.

While technical language has so far as possible been avoided, the author trusts that there will not be any sacrifice of scientific thoroughness. The recognized authorities, by no means merely chosen for their agreement with the views of the writer, have been consulted and a glossary of the few unusual terms employed, is supplied at the end of the book. An acknowledgement of gratitude is hereby made to those friends who have so kindly aided the work by suggestions or otherwise. The author wishes to thank in particular his sister, Miss B. Kreidel, for her not inconsiderable share in the final preparation of the manuscript for publication.

G. A. K.

Dunwoodie, N. Y.,
Nov. 18th, 1921.

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INTRODUCTION

The Point of View

All men are privileged to enter the archives of Creation in order to view and examine the records of the universe from the time of its inception down to the present hour. Among the many volumes is one that is read by comparatively few and very often misunderstood. It is the great book of Nature, on whose pages have been written countless activities and phenomena which are startling and should hold the attention of the reader. However, as facts or phenomena alone they are not likely to make a lasting impression, because in and of themselves they have only a relative value. They may satisfy a momentary curiosity, but eventually memory will not recall them. What the human mind desires in addition to the facts is an interpretation, a meaning of it all, in other words, a central idea around which the interesting data may be grouped. Like the

bricks of a house the phenomena of Nature are merely individual units which go to make up some general structure of thought. Again, they constitute "at most a cold catalogue which we must thaw and quicken at the fire of the mind; we must introduce thought and the light of reason; we must interpret" (Fabre).

Various writers have consulted the book of Nature for the purpose of emphasizing some fundamental idea or theory, and in this manner have commanded the attention of the general reader. But their viewpoint does not always meet with approval, and very often the serious-minded have protested most vehemently against the peculiar interpretation of the facts. The mode of reasoning proves unsatisfactory because a spurious code was employed in the procedure. Such works may be compared to the endeavors of a great scientist of the 17th century, who in all sincerity deciphered the hieroglyphs of the Egyptian obelisks in Rome according to the then prevalent standards of interpretation. Although his rendition was plausible and scholarly, subsequent events showed that it was far from the truth. It was only after the year 1799, when the Rosetta stone was discovered, that the real significance of the inscriptions became manifest.

INTRODUCTION

The writings of certain modern authors contain unwarranted misrepresentations, and to all appearances the element of sincerity was given little consideration. Erratic opinions are put before the public and the results of scientific investigations are introduced to supply the details. Their ideas may be well developed and seem plausible to the unwary, but the right code has been either entirely ignored or treated with disdain. They dismiss a Rosetta stone which tells them that the idea of a Creator must not be omitted. Their publications give ample proof that a little knowledge is a dangerous thing. They raise the cry, "Science for science's sake," yet they themselves employ the facts of science to defend some strange philosophical point of view. But "it must not be forgotten that the facts are not disputed—all the arguments and wranglings come from what these facts mean, and meanings are and must always remain in the realm of philosophy" (Menge).

One of the most famous instances which might be mentioned, is that of Ernest Haeckel the apostle of Monism. As a scientist, he had done some remarkable work in his particular sphere and credit must be given to him for his endeavors. But when he crossed the barriers and appeared

before the public as a great "philosopher," he lost the esteem that men would have had for him. In his writings and discussions he made use of the facts of science to bolster up an idea, which has created disturbances of far-reaching consequence. When there were no facts available to prove his point, his own imagination produced them, or else, he stooped so low as to forge the evidence. In the preface to his work, "The Riddle of the Universe," he wrote: "In taking leave of my readers, I venture to hope that through my *sincere* and *conscientious* work. . . . I have contributed a little towards the solution of the great enigma." But the two traits which we have purposely *italicized* are not to be found in Haeckel's works. In his book on the "History of Creation" he fraudulently employed illustrations with slight modifications of his own design, to represent similarities of three different forms of embryonic development. This deception and others were discovered by Professors His and Rütimeyer, the former remarking. "Let others honor Haeckel as an efficient and reckless party-leader; according to my judgment he has forfeited through his methods of fighting even the right to be counted as an equal in the company of serious investigators." Haeckel, however, did not re-

form his ways, as became evident in a later work: "The Riddle of the Universe." He used "quotations" of an alleged English theologian, employing the pseudonym "Saladin," who never existed. When called to task he omitted the "quotations" in the English editions but retained them in the German. Despite protests he persisted in his unscrupulous methods.

What was the reason for all this *"sincere and conscientious work"?* Haeckel together with his sycophants bore a rabid hatred towards everything theistic or Christian. He endeavored to prove that no God created the world, or even existed, and that Christianity is only a "rich and variegated polytheism that dwarfs the Olympic family of the Greeks." This was the root idea of all his endeavors and the remarks did not appear in scientific works, but in those destined for the general public, where he was certain that his readers were not in the position to estimate true scientific values.

The facts of science do not warrant the deductions proposed by Haeckel and his adherents. Rather, when prudently considered, these facts lead to the idea of God, the Ruler of Heaven and earth. This conclusion was admitted long before the appearance of many alleged scientific

dissertations and will be the opinion held by every scientist who views the facts judiciously.

The impression may yet remain in the minds of some that the study of the natural sciences leads logically to irreligion. To substantiate their view they will tell us that many of the prominent scientists defend materialistic principles. It cannot be denied that many who are heralded as able scientists, may be so inclined. But they are not all classed among the representative scientists, and experts may not consider them worthy of passing judgment on serious questions. These so-called able men have materialistic tendencies, not on account of the science which happens to be their specialty, but on account of the background they have adopted for their argumentation. In their treatment of the subject-matter, they start out with the idea that there is no Divinity, or that none was needed, and carry this view to what seems to them a logical conclusion. Against them we would advance savants whose names are recognizable as the very greatest in scientific endeavor and achievement. Such have never thought that their scientific knowledge, no matter how profound, was inconsistent with their religious faith, however simple. On the list are noticed Haüy, the father of

scientific crystallography; Herschel and Faye, the great astronomers; Steno, the founder of geology; Malpighi, the founder of physiology; Vesalius, the founder of modern anatomy; Harvey, the discoverer of blood circulation; John Müller, the greatest physiologist of all times; Schwann, the founder of the cell-theory; Cuvier, the founder of modern comparative anatomy; Linnaeus, the founder of modern botany; Pasteur, the prince of investigators and the founder of bacteriology; Mendel, the formulator of the law of heredity; Fabre, the entomologist; Mme. Curie, the discoverer of radium. The list is by no means exhausted, but space forbids further details.

A passage quoted by Professor Menge in his book "The Beginnings of Science" deserves consideration. "The half-educated man, who is smoothly borne along the streets in an electrical car, who from his room converses with a friend miles distant and recognizes his voice, who sends a message to America from Australia, far in advance of the fastest train or steamboat, this man often smiles with a sneering and superior look, when he sees an old woman telling her beads, or when the conversation turns on priests and church, and he thinks that the great discoveries of this age of electricity have given the death-

blow to the old religious prejudices. But by so doing he betrays his ignorance; he forgets that the great intellects to whom, in the first place, these great modern achievements are due, have humbly meditated on and bowed before the truths of Christianity. And the clever hands under whose touch the hidden forces of electricity first manifested themselves, have often closed in humble prayer, and in the instance of Volta and Ampère have not disdained to hold the beads." Francis Bacon reminds us: "A little philosophy (i. e. science) inclineth man's mind to atheism, but depth in philosophy bringeth men's minds about to religion." Hence, Pasteur could declare: "The more I know, the more nearly is my faith that of a Breton peasant. Could I know all, I would have the faith of a Breton peasant woman."

There is no reason why the above should not be the case. The true believer has nothing to fear from science, whereas, in point of fact, it must be said that he cordially welcomes every advance in natural knowledge. If there were any antagonism between science and religion, the Church would never have fostered natural science in past centuries; the famous universities of Europe—Aberdeen, Glasgow, Oxford, Cam-

bridge, Paris, Louvain, Salamanca and Bologna—would never have been founded by the Popes. The enlightened occupants of the Chair of Peter realized full well that in the whole range of natural science, there was no single known process, no law of Nature, which seemed counter to revealed religion. The antagonism arose only when a direct attack was made on religion or when men confounded the natural and the supernatural and began to treat as established facts many statements which, on fuller consideration, could not be accepted. These men overstepped the boundaries of science and attempted to prove certain points in a region where their methods could not be applied.

True science remotely at least deals with the objects of sense, and although God transcends sense, nevertheless, according to St. Thomas, objects that appeal to the senses are the basis of our demonstration of the existence of God. Such a demonstration has been attempted in the following pages. The facts taken from the book of Nature are grouped around that all-important idea, which is sought in vain in many works of our day. Haeckel disdainfully called it an "irrational superstition," but renowned and prudent men have acclaimed it the essential and

true. The study of the natural phenomena does not weaken our belief in an all-powerful and all-wise God. On the contrary it prompts us to show Him greater honor and respect and to proclaim with the Psalmist: "Lord, before the mountains were made or the earth and the world were formed; from eternity and to eternity thou art God" (Ps. lxxxix, 2).

CHAPTER II

GOD IN NATURE

THE natural sciences were formerly considered the exclusive field of a few specialists, who had chosen this work as the object of their life's study. But the progress of these sciences has been great and the results attained so significant, that even the general public shows interest and tries to familiarize itself with the facts. For that reason many works are written in popular language and find their way into the family library. These books show in what manner the results of scientific investigations are being employed for the economic betterment of mankind, or how they support or refute some philosophical opinion. The physicist has shown how the forces of heat and water can produce steam, which propels the giant ships of the sea and the iron monsters of the land. Steam-power has brought about an industrial revolution. Since the days of James Watt a new civilization has arisen, quite different from any which have previously existed in the world. Our

modern industrial centres would not exist, our acquisition of foreign products would not be so abundant and varied, if it had not been for the steam engine. After many modifications and improvements, it is now a mechanism of high efficiency. In watching the motion, to-and-fro, of the crosshead of a reciprocating engine, or, in listening to the faint purr of the turbine, a person realizes something of the marvellous adaptability of steam and perhaps wonders why its value was not recognized centuries ago.

The chemist has made known some of Nature's most carefully guarded secrets. With the help of the physicist, he has given to the world the internal combustion engine. Daimler invented the first practical light oil engine, and his original motor was produced in 1866. Since then, there have appeared many forms, so that now there are types for domestic use, types for the motor car and flying machine, and types for the submarine and other vessels, as seen in the renowned Diesel engine. Besides this invention, chemistry has made other discoveries, like the many compounds used in the industrial and medicinal departments. In the biological laboratories may be found the keen and patient observer, who, with scalpel, microscope, and reagents, studies the

structural and functional phases of organisms. Such observations may be of greatest importance in the branches of pathology, hygiene and sanitation. The astronomer searches the heavens in order to verify previous observations or to augment the data furnished by his colleagues. Thus, there are triumphs and discoveries in every branch of scientific endeavor, and we are asked to marvel at the wondrous works of Nature.

Before giving our complete approval to this last statement, it will be necessary to consider the word "Nature." It is likely to create confusion because of the different meanings men attach to it. Caution must be exercised, lest assent be given to some proposition which is altogether unfounded. The varied use of the term is readily seen in Darwin's "Origin of Species." In the third chapter he makes mention of animals "in a state of nature"—that is, animals not domesticated. Then he refers to species "as arising in nature," as if they were produced spontaneously in an environment outside of the organic world. In another place, he speaks of animals as given to man "by the hand of Nature." He also states that the works of Nature are superior to those of art. Here Nature apparently signifies some power equal or superior

to human intelligence. A similar expression is used by Darwin's great pupil, Romanes, when he explains the mystery of progressive development in Nature. He writes: "Nature selects the best individuals out of each generation to live." Unless Nature means some intelligent agent, the phrase would be difficult of interpretation. Greater consistency would be shown in all these modes of expression if the word "Nature," as here employed, represented the manifestation of an Almighty God, who foresaw and arranged everything from the beginning. We are willing to marvel at the wondrous works of Nature, because, as Seneca says, Nature is a "certain divine purpose manifested in the world."

Many persons are satisfied with the explanation that all the various phenomena are the products of Nature's laws, and by some these laws are considered inexorable and immutable. But it must be made clear that the "laws of Nature" are neither powers nor forces which influence things, nor, are they decrees like the Ten Commandments or legislative measures. They are merely generalizations of our own, and, as Professor Windle says, "express our appreciation or conception of an orderly or supposed orderly sequence of events in the natural world." Laws,

as understood by science, are deductions made from observed modes of action.

There are numerous events in the world of Nature which proceed in regular order and these permit us to draw some definite conclusion. As Ganot remarks: "Every change which can happen to a body, actual alteration of its chemical constitution being excepted, may be regarded as a *physical* phenomenon. The fall of a stone, the vibration of a string and the sound which accompanies it, the attraction of light particles by a rod of sealing wax which has been rubbed by flannel, the rippling of the surface of a lake, and the freezing of water, are examples of such phenomena." ("Physics.")

The constant relation existing between any phenomenon and its cause is spoken of as a physical law. "As an example, we have the phenomenon of the diminution of the volume of a gas by the application of pressure; the corresponding law has been discovered and is expressed by saying that the volume of a gas is inversely proportional to the pressure, if the temperature be constant." (*Ibidem.*) Similar laws have been formulated with regard to heat, motion, attraction, and gravity.

Laws like the above may be found in other

branches of natural science and they are based on present experiences. But as such they are not of necessity. Perhaps different laws may have to be formulated for parts of the universe not accessible to us at the present time. The results of further investigations may make known new facts, that will cause the law to be modified and changed considerably. Guenther in his "Darwinism and Problems of Life" says: "Science deals with probabilities as well as exact observations. When it deduces a law from a number of phenomena that it has observed, it *assumes* that this law will hold also for other phenomena of the same category, and this assumption in turn implies that there are general laws which apply universally and unconditionally. This, of course, can never be proved. It is possible that new observations might be made that compel science to rearrange all its laws. However that may be, physical science is not absolute and unconditional, because it *supposes* that what is true in a thousand cases, will not prove untrue in the next one." In a footnote he writes: "The laws of science must not admit a single exception. In this case the law is not confirmed, but completely destroyed." Hence the fact that phenomena occur according to certain fixed laws at the

present time, gives no assurance that they could not take place in accordance with some differently worded deduction.

The mode of occurrence of various phenomena shows regularity and uniformity and causes us to infer that there is an external influence guiding all things. An example drawn from human activities may illustrate the case. In one of the unfrequented quarters of the famous Woolworth Building in New York, a dispatcher is found sitting at a contrivance somewhat like a telephone switch-board. Instead of the orifices for wiring connections, this board has a number of translucent knob-like arrangements, behind which a light appears at intervals. The one employed in this task watches the light intently, as it travels up and down the different rows, and from time to time she is heard to give instructions. She has the entire system of elevators of that immense building under her control and it is her duty to regulate their movements. The necessary directions are given to the operator of each lift by means of the telephone. In this manner, the dispatcher determines the times and the distances and decides which elevator shall wait at one or the other floor. She also inquires concerning delays, etc. Here we have an unseen guiding in-

fluence, who, in a way, has control not only over the individual operators, but also over the mechanical contrivances and the electricity that moves them. It is similar in the world of Nature, and this illustration gives only the faintest idea of the numerous interactions and interdependencies which may be known or unknown. Nature is one vast entirety with parts inseparably connected and related, and is governed by laws. These laws, we claim, are the highest evidence of Power and Divinity, as well as the realization of the plans of an All-wise and Eternal God.

The ends to be obtained in Nature may not always be known, and it would appear as if all the activities could not be regulated by such a Superhuman Intelligence. This, however, is owing to the limitations of the human mind. The interactions and adjustments of laws are of different grades. Furthermore, they are so varied and complex in their scope, application, and possible combinations, that we are unable to calculate their results. Yet, this gives no justification for disregarding divine influence.

There are some who will find fault with this mode of reasoning and claim it to be an anthropomorphic fancy, into which the "mystic" element

has been introduced. Such persons forget that all science is built up in the same manner. All our conceptions of the wonderful uniformities or laws in Nature are based on experience, and science relies on what we know of Nature through the medium of our senses. Accordingly, science consists of that which we think of Nature, as presented to us, and it is human reason which has made the deductions. This power of inference enables us to realize that we are a part of Nature, that we belong to the unity of a great plan, and are in harmony with other parts. Were our minds not so attuned, there would be no guarantee for the absolute truth of scientific facts and principles.

By the same mode of reasoning the human mind has drawn the conclusion that Nature is a manifestation of Divine Power and Wisdom. This idea is not of recent date, nor limited to certain peoples. On the contrary, it is ancient and universal. Man from time immemorial has noticed something analogous between the operations of Nature and those of his own volition and design. He has concluded, from the facts observed, that these natural phenomena, varied though they may be, show a uniformity and com-

plexity difficult for him to understand, and to him they imply a First Cause infinitely beyond himself.

Even savages and primitives have come to this conclusion. They have a belief in the "Man above the clouds," meaning thereby the Maker and Creator of all. The Veddahs of Ceylon refer all to the "Great Spirit," the inhabitants of Malacca and the Andaman Islands speak of "Our Father," whilst the primitives of Australia and Central Africa pray to the "Father of all." Bishop Le Roy, in his work "Les Pygmées," states that in the Congo he found no group to which the idea of the Creator was unknown.

Ancient monuments and writers show that among the more cultivated races the idea of a God was always prevalent. In the ruins of Telloh, in Mesopotamia, there have been found thousands of bas-reliefs, statuettes, and inscriptions giving the history of ancient Chaldea. Dr. F. Delitzsch ("Babel and Bible") writes that some of the finds date back to the fifth millennium before Christ. One of these tablets has a record of the Chaldean king Ur-Nina, who, wishing to erect a temple to the Divinity, worked at it with his own hands. In fact, the earliest monuments among all peoples have references to

a deity. It is significant and important to note that the farther back the history of any people is traced, the more there is recognized the profound and wide influence of religion in the life of individuals. Plutarch exclaims: "There can be found cities without walls, without a literature, without kings, without treasures, without coins, without theatres, or schools of athletics, but a city without a sanctuary, without a deity, without prayer, without oath, without prophecies, without sacrifices for obtaining favors or averting evils, such a city no one has seen and no one will see." ("Contra Colotem," ch. 31.)

The famous Roman orator and philosopher Cicero remarks: "The main reason for the belief in the gods could be that no people is so wild, no man so uncouth as to be destitute of every conception of the gods. Some, indeed, have formed objectional representations of the gods; this is the result of corrupt morals; but all are convinced of the existence of a divine power and a divine being. This conviction was not brought about by an arbitrary agreement of men; it has its foundation neither in instruction nor legislation, but rather, this common knowledge is a natural law to all peoples." ("Disp. Tusc.," I, 13.)

The great Roman empire gives abundant proof

that the old world was religious. The state was founded on religion. At all the important transactions the gods were consulted, sacrifices were offered and religious rites observed. The emperor Augustus expressly decreed that every senator, before taking the oath of office, should go to the altar of the deity in whose temple the assembly was held and offer a libation and strew incense. (Suetonius, "Augustus," ch. 35.) The army going to battle received inspiration from the ancestral deities. When the great Pompey spoke to his soldiers on the art of war, they remained unmoved, but when Cato reminded them of the *dii patrii,* he aroused enthusiasm and confidence, so that victory was won.

In a similar manner the domestic and family life of a Roman had a religious tone. Each period of life, every important event was celebrated with religious services. The goddess Lucina watched over the birth of the child; at such times candles were lighted in honor of Candelifera; Nunlina was invoked on the ninth day when the name was given; Potina and Educa accustomed the child to food and drink; Farinus taught the child to lisp; Locutinus to talk. Special gods were supposed to watch over the family and every community, every city had its special

cult, rich and distinguished colleges for priests as well as special feast days and sacrifices. Everywhere religious observance was intimately connected with important activities and events.

When this variegated and rich development of polytheistic belief was at its height, St. Paul, the Apostle to the Gentiles, appeared before the Areopagus at Athens to speak of the one true and only God, the Lord of Heaven and Earth. Concerning Him he writes to the Romans: "The invisible things of him, from the creation of the world, are clearly seen, being understood by the things that are made" (ch. I, 20). Tertullian says: "Nature is the teacher, the soul the pupil." Athenagoras calls the things of Nature "pledges of divine worship" and says, the "visible is the medium by which we perceive the invisible." St. Chrysostom exclaims: "Did God call the Gentiles with his Voice? Certainly not. But He has created something which is apt to draw their attention more forcibly than words. He has put in the midst of them the created world and thereby, from the mere aspect of visible things, the learned and the unlearned, the Scythian and the barbarian, can all ascend to God." ("Homily on the Epistle to the Romans," no. 2.)

Some of the learned of our day are likely to

dispute this point, being convinced that Nature presents a number of opposing forces which do not give evidence of a great and regulated external influence. But when the facts are examined more carefully, it can be seen that everything is balanced by the most wonderful interactions of matter and forces. Behind it all there is a law, according to which everything occurs with invariable regularity and constancy.

When some substance, like water, condenses from a vaporous state in the atmosphere by the action of cold, particles unite and form solid figures. Heat had kept them asunder, but a cohesive force unites them. Not only do the particles unite, but they form solid objects, called crystals, which can be seen in snow and ice formations. Such crystals always possess the same definite outline when coming from water. In fact, according to Haüy's law, "every crystalline substance of definite chemical composition has a specific form characteristic of that substance." H. P. Gurney remarks: "In whatever manner, or under whatever circumstances, a crystal may have been formed, whether in the laboratory of the chemist or in the workshop of Nature, in the bodies of animals or in the tissues of plants, up in the the sky or in the depths of the earth, whether so

rapidly that we may literally see its growth, or by the slow aggregation of its molecules, during perhaps hundreds, perhaps thousands of years, we always find that the arrangement of the faces of the crystal and therefore its other physical properties, are subject to fixed and definite laws."

In Nature there are also varied arrangements and activities that operate together for a common good. No more wonderful instance can be found than the green leaf of a plant, which has well been called an elaborate chemical laboratory. Under the microscope, it is seen that a thin layer of compact cells surrounds the leaf on all sides. This skin has very small openings, which are provided with lens-shaped cells, called "guard-cells." By means of these minute pores access is afforded to carbon dioxide, and oxygen can escape. These openings communicate with any number of air-spaces that run in all directions in the spongy mass of cells beneath the layer. For the most part, the interior mass of cells possesses numerous green bodies which give the green color to the leaf. Moreover, the leaf is connected with the main part of the plant by means of the stem, whose outer portion is usually green, similar to the leaf. The inner portion of the stem known

as the pith consists of delicate cells which conduct water for a short time and soon die. The zone between the two just mentioned, is the great conducting region and this also gives rigidity to the stem.

Although the structural portion of a leaf shows great beauty and complexity, its functions are even more wonderful and perplexing to the botanist. This is true especially of the green bodies, which construct the most important foods of the plant. One scientist calls it the "leading wonder of the world, because its processes are so complicated and of such magnitude and importance in the economy of this world of ours." (Curtis, "Nature and Development of Plants.") By way of the stem the leaf receives water from the soil, with materials in solution. Gases enter the leaf through the minute openings in the thin outer layer. The green bodies change these substances chemically and as a result there are produced complicated and otherwise inimitable compounds. Professor Curtis says: "All that can be definitely stated about the change going on in the leaf during the formation of the carbo-hydrates relates solely to the beginning and end of the process." Water and carbon dioxide enter the cells having green bodies, and "a series of changes

follows, the nature of which can only be conjectured."

The energy which brings about this remarkable transformation comes from the sun. Its light and heat are freely admitted into the interior of the leaf through the transparent outer skin. In this way, all the materials available for the maintenance of life are produced and no other structure than the living vegetable cell, as it exists in the leaf, is capable of effecting this change. This process is, therefore, of greatest importance, since the existence of plants, animals, and man depends on it. What happens in such a subtle way as not even to attract our attention, is that the vegetable cell is placed in relation with the entire plant, with the soil, and with the sun and its energies. *Photosynthesis* is the name of the process, and it means "the putting together by means of light." This solar energy acting in conjunction with the green bodies on a few elements, gives us the great variety of compounds found in plants and animals and man.

A further evidence of a Superior Intelligence is furnished by the beauty of form, proportion, and coloring that abounds in Nature. Our Lord Himself tells us: "Consider the lilies of the fields, how they grow; they labor not, neither do they

spin. But I say to you that not even Solomon in all his glory was arrayed as one of these" (Matt. vi 28-29). St. Augustine, commenting on the Epistle to the Romans, wherein St. Paul speaks of those who, knowing God, have not glorified Him, asks whence they do know Him, and responds: "From the things He made." Then he exclaims: "Ask the beauty of the earth, ask the beauty of the sea, ask the beauty of the diffused atmosphere, ask the beauty of heaven, ask the order of the stars, ask the sun illuminating the day with its brightness, ask the moon softening with splendor the ensuing night, ask the animals that move in the water, that live on the land, that fly in the air. . . . Ask them. They all answer: Behold, we are beautiful. Their beauty is their confession. Who made these changeable beautiful objects, but the Unchangeable Beautiful One?"

Suffice it to mention one of the animal forms "*quae moventur in aquis,*" according to the Bishop of Hippo. It is the "Slipper Animalcule," whose existence was not even suspected by the great Luminary of the Church, because the microscope detected it only centuries later. The animal is no more than about 1/125 of an inch in length, but it has been made the basis of scientific

discussions of cell-structure and cell physiology. It has the outline of a tiny slipper and is found in stagnant pools of fresh water in all countries, and can be procured in the laboratory by placing a quantity of the hay to which it is attached, in a jar of ordinary water, and permitting it to stand for a few days. The microscopic animal consists of only one cell and has a definite shape; it swims freely in the water along a spiral path. Attached to the outer portion of its body are numerous hair-like structures, that move with great rapidity. They are the organs of locomotion. In a groove leading to the digestive system are other hairs, which by their action send particles of food down the short gullet.

When the food has passed in, it is immediately surrounded by a little drop of water and floats about in the interior of the soft and semi-fluid body. While the food is being carried around in this manner, a digestive fluid breaks up the food particles by chemical action, so that they may be assimilated and build up the bodily structure. By certain channels the waste products are brought to pulsating sacs, one at either end of the body, which contract alternately. When the sacs are filled to capacity, they burst at the surface and the waste is poured into the water out-

side. Here is a brief description of only one of the animalcules showing a beauty of construction and coordination of functions. It could not have arisen spontaneously, but points to a Higher Intelligence, which created it.

Another fact to be cited, which however, will be treated more fully later, is that of animal instinct. The remarkable behavior of many animals shows us how these creatures are placed in relation to other objects and to most complex processes. Notwithstanding assertions to the contrary, instinct by its very nature cannot be improved upon. Invariably it works in the same manner, and if interfered with, proves useless for the purpose. It is inherited by each generation in all its perfection, and the offspring shows the same instinctive qualities as the parent. To compare instinct with human intelligence is erroneous. Simply to state that it began in the past proves unsatisfactory. To assert that Nature has made these provisions, means nothing, unless Nature represents the revelation of a Superior Creative Intelligence that regulates the world in which we live.

Therefore, the phenomena of Nature can be rightly interpreted only if the point of view be accepted that they proclaim the Majesty and

Glory of Almighty God. Aptly does the Book of Wisdom say: "All men are vain, in whom there is not the knowledge of God: and who by these good things that are seen, could not understand him that is; neither by attending the works, have acknowledged, who was the workman. But have imagined either the fire or the wind or the swift air, or the circle of the stars, or the great water, or the sun and the moon, to be the gods that rule the world. . . . For by the greatness of the beauty and of the creature, the creator of them may be seen, so as to be known thereby. . . . But then again they are not to be pardoned. For if they were able to know so much as to make a judgment of the world: how did they not more easily find out the Lord thereof?" (chap. xiii.) Human reason enables man to explore the universe. This same reason should infer from the beauty, magnitude and harmonious activities in the world, that there must be a Creator who fashioned it. For according to the Book of Wisdom, human beings can obtain a knowledge of God's existence and attributes from the world of Nature, and Cicero says: "Whatever Nature teaches must be true." ("De Nat. Deor.," 1, 17.)

CHAPTER III

THE BEGINNING AND THE END OF THE WORLD

THE starry firmament, as seen on a clear night, with its innumerable twinkling bodies possessing a greater or lesser degree of luminosity, has attracted the attention of mankind since the days of antiquity. The origin of the celestial spheres, their constituent elements, their disappearance and reappearance at regular intervals, have long since been a source of speculation and have given rise to various cosmogonies. The Bible relates that in the beginning the "earth was void and empty and darkness was upon the deep." On the successive days of Creation the Almighty brought shape and order out of chaos, and on the fourth day the heavenly bodies appeared.

Since the Book of Genesis does not give a detailed description of the emergence of the stellar bodies from the original void, man has endeavored to form some conception of their mode of origin. Even the benighted savage has not

been content to take the world as it is, without forming some theory, infantine and crude though it be, with regard to its initial formation. Various opinions are held by the civilized peoples of our day. Many say that the physical universe has come from the hands of God exactly as it is found at the present time. They are justified in their view, because God, the Omnipotent Creator, could have acted in that manner. Others, not detracting from His attributes in any way adhere to the view that the world in its present state was not completely formed by Him, but attained this arrangement through the operation of secondary causes. Scientific investigation has done much to strengthen the latter opinion. It must be remembered that this phase of the history of the world is speculative and does not go beyond the limits of an hypothesis. According to the observations and calculations made, three principal views have been put forward to account for the development of the solar and stellar systems. They are known as the Nebular, Meteoritic, and Planetesimal Hypotheses.

A form of Nebular Hypothesis was proposed by Immanuel Kant, when he was only twenty-four years of age. On account of his inexperience and lack of knowledge of mechanics and

physics, his work, "The Theory of the Heavens," required considerable revision. Yet, his scheme propounded long before the period of "pure reason," with all its deficiencies, bears the authentic stamp of genius—of a genius imperfectly equipped with knowledge, but original, penetrative, and far-seeing. Since the ideas approach very closely to those enunciated by great astronomers equipped with the necessary knowledge, the details need not be considered here.

According to the hypothesis of Laplace, modified by Faye,—now commonly known as the Laplacian or Nebular Hypothesis—all the atoms which compose the physical universe were at one time scattered and formed the constituent parts of an immense nebula diffused throughout space. This rarefied mass contained all the elements of terrestrial chemistry, as well as the constituents of the other planets, but they were more or less mixed and in a chaotic state. The materials of the nebula were attracted to each other and in time, owing to diverse movements, patches or clouds were formed. These continued to move and within them there also occurred slow gyrations. Gradually, by progressive condensations, the different patches gave rise to the worlds of the universe.

Our own solar system is supposed to have emerged from one of these clouds. The mass is said to have been so rarefied as to measure only a small fraction of a millionth of the density of our atmosphere at the surface of the earth. The extreme degree of rarefaction was maintained by an intense heat, produced by the slow circular movement. A gradual loss of heat caused the cloud to contract and to rotate with greater rapidity. When the radiating or centrifugal tendency had gradually equalled the centripetal acceleration—or pull of gravity—the outermost portion of the nebula no longer contracted, but was "thrown off" in the form of a ring, similar to the rings of Saturn. The remainder of the cloud continued to contract because of further loss of heat, and eventually more rings were given off. As the cooling and contraction went on, there arose rings equal to the number of planets now existing in our solar system, and the central mass, namely, the uncooled portion of the original nebula, formed the sun.

The rings, fashioned in this manner, probably revolved for a time in their entirety. As they cooled still more, they parted at their weakest point. The material of each ring concentrated, gradually became more compact, and finally

fused into spheroids, which were still hot and gaseous. In other words they were embryonic planets that resembled the sun, which is said to be a "mass of intensely heated gas and vapor, powerfully compressed by its own gravity." These bodies also contracted, smaller rings were abandoned, and as time went on, they experienced changes similar to those of the former large annulations. The secondary rings were to give us the satellites. However, the nebulae of Mercury and Venus did not produce rings for the formation of satellites. Only the planetary masses at a greater distance from the sun: the earth, Mars, Jupiter, Saturn, Uranus, and Neptune, furnished secondary bodies of this type.

Accordingly, the earth at first was a globe of highly heated vapor. When it had lost the materials that gave rise to the moon, it slowly condensed, owing to the fact that its elements fell toward the centre. It was then in a liquid state, and for a long time it must have been incandescent like a star. The loss of heat caused it to cool to a degree which permitted the formation of a crust upon its surface, whilst the interior still remained liquid. After the solid crust covered the surface of our earth, there were in-

troduced the various geological phases.[1] Regarding the origin of the moon, two explanations are offered. The one is that both the earth and the moon were contained in the original ring given off from the immense nebula. This ring was changed into a hot gaseous spheroid, which later gave off a second ring to form the moon. The other view is that the moon was not detached as a ring, but was "thrown off" as a large lump or a series of fragments, after the earth had concentrated to a liquid or perhaps even to an incipent solid state.

This explanation of the origin of our solar system has found favor since the very date of its publication. Laplace's great name and the unique value of his work on celestial mechanics, led to the acceptance of his ideas. Hence the greatest physicists and astronomers of the nineteenth century have given the weight of their approval to the Nebular Hypothesis, and all calculations as to the age of the sun have been based upon it. Among other facts that support this view might be mentioned the hot condition of the interior of the earth. Molten rock has been extruded from it at various times throughout the different geologic ages. Again, the earliest known

[1] See the geological time table on page 263.

rocks—as in the Archean Complex—are igneous, or igneous derivatives.

The Nebular Hypothesis retained its commanding position until Chamberlin and Moulton, two American scientists, advanced some weighty arguments against it. An old objection to the hypothesis is that all the satellites of the various planets should revolve in the direction in which their planets rotate. However, the satellites of Uranus and Neptune and the ninth satellite of Saturn travel in the opposite direction. Furthermore, the planes of the four satellites of Uranus are almost perpendicular to the plane of the planet's orbit, and this seems to be directly opposed to Laplace's views, which describe all the stellar bodies as travelling in the same direction. Then we are told that Phobus, the inner satellite of Mars, revolves in less than a third of the time of the planet's rotation, whereas the hypothesis would require its velocity to be much less than that of the planet's surface. Phobus travels around its planet in 7 hours, 39 minutes, and 15 seconds, while the period of Mars' rotation on its own axis is 24 hours, 37 minutes, and 22⅔ seconds. So also, the particles, that make up the inner ring of Saturn, revolve in about half the time of Saturn's rotation period.

It is further argued that the molecules of a gas move about at velocities which increase with the temperature. Near the surface of the original nebula of Laplace, the velocities of the molecules, as, for example, in hydrogen, would be so great that the molecules would overcome the pull of gravity and be dispersed in space. Hence, it would be difficult to account for the abundant supply of hydrogen now observed in the sun and for formation of the various rings in the original nebula. Moulton also applied these principles to the planets with regard to the power of each to retain an atmosphere. He does not consider it probable that the diffuse earth-moon ring, with its low power of attraction, could have held any of the atmospheric gases or water-vapor, when such concentrated bodies as the moon, and perhaps Mercury, are unable to hold an atmosphere at the present time.

The average density of the original nebula, when it extended to the orbit of Neptune, can be approximately calculated, since the masses of the sun and planets are known. According to Moulton, this density was about $\frac{1}{191,000,000,000}$ of that of water. It is argued that in this rarefied condition matter would have been left behind continually and that the formation of separate

rings would be impossible. He also holds that even if a ring had been formed, its elements could probably not have been drawn together into a planet.

Although the above facts may be open to question, Moulton offers another objection which demands serious consideration. It is a law of mechanics that the moment of momentum, or quantity of motion, of any freely rotating or revolving system of bodies, remains constant, unless influenced from without. In this connection our scientist wants us to assume that the present solar system could be changed into a gaseous mass, expanded so as to fill Neptune's orbit, and distributed in density to agree with the recognized laws of gases. If, then, the whole amount of motion now possessed by the solar system be given to such a nebula, there will not be a sufficient rate of rotation to detach matter from its circumference. The required rate would not be present until the nebula had contracted well within the orbit of Mercury, which is the innermost planet. Therefore, according to some, the Laplacian idea of the development of the solar system must either be reconstructed or abandoned.

As substitutes for the Laplacian view, there are given two hypotheses, the one called the Me-

teoritic, developed by Lockyer and G. H. Darwin, the other, the Planetesimal, proposed by Chamberlin and Moulton. Both of these hypotheses assume that swarms of meteorites,—rather than matter in a gaseous state,—composed the raw material of which the stellar systems are made. The nature of the swarms is explained differently. Lockyer holds that the meteorites were like the wandering molecules of gases which moved indiscriminately in all directions and at widely different velocities. Furthermore, these bodies in their rapid movements collided with one another from time to time, just as the molecules of gas are supposed to do according to the kinetic theory. On the other hand, Chamberlin and Moulton claim that the meteorites revolved in well defined orbits, and collisions occurred only when certain meteorites overtook others of lower velocity.

The Planetesimal Hypothesis, which seems the more plausible, holds that the solar system was derived from a nebula of the most common type, namely that of the spiral nebula. There are about 120,000 of these spiral nebulae registered in the heavens, and their peculiar form is said to represent a prevalent process in celestial dynamics. Moulton's view begins with a fully organ-

ized sun, which in its movement through space came into close proximity of another sun of equal size or larger. Perhaps there was even a "grazing collision." There was, moreover, an attraction between the two bodies causing tidal action, with the result that portions were given off at high velocities, never to return. Further attraction caused the separated material to acquire a spiral form, in which the scattered particles revolved in elliptical orbits about a central mass. Although the matter shot from the sun was gaseous, the hypothesis assumes that it cooled down rapidly to a finely divided solid condition. In such a spiral nebula, which appears like a pyrotechnic "pinwheel," there are different elements or degrees of density: a central mass, knots, and diffuse nebulous matter. In the primeval spiral nebula of Moulton, the central mass is supposed to have formed the sun, the knots served as nuclei about which the planetary material gathered, and the remaining diffuse matter was to have been swept up by the nuclei or absorbed by the sun.

Thus, the building up of the planets occurred by the gradual ingathering of the small particles called planetesimals or "little planets," in the

form of molecules or small bodies. The results were brought about not only by the gravitational attraction of the planetary nuclei, as in the nebular hypothesis, but also by the gradual accretion of the mass through collision of isolated particles, as they were crossing each other's paths. The earth, in that case, was never a molten substance, which cooled and contracted, but it was gradually built up by the accumulation of more and more particles.

In its early stages our globe had no atmosphere, because its small mass was not capable of holding gases by the attraction of gravity. The gases, on account of their activity, were lost in space. As the earth grew by the addition of more matter, the gravitational attraction increased, so that it could bind to itself greater volumes of gases, until the present condition was reached. Even now two gases, hydrogen and helion, are superior to its attraction. Comparisons are made to show the size of the earth when it could hold the atmospheric gases. The moon at present is about the $1/81$ part of the earth's size and has no atmosphere. On the other hand, the planet Mars is $1/9.34$ as large as the earth and is said to have an appreciable, though apparently quite

limited, atmosphere. Our earth, therefore, must have been between $\frac{1}{80}$ and $\frac{1}{10}$ of its present size. Probably it was about the $\frac{1}{20}$ part, since the planet Mercury, which is $\frac{1}{26}$ of the earth's mass, seems to show a slight evidence of water-vapor.

Regarding the origin of the atmosphere and the earth's waters, an explanation is also given. The elements came from the original sun and the planetesimals, upon condensing, held within them the atmospheric material. When they struck the earth, heat was produced and this caused part of the gases to be given up. When our globe was of sufficient size, it held this material in the form of an atmospheric envelope. The portions of the gases retained by the planetesimals were gathered into the growing earth-nucleus and were progressively given off to the atmosphere. When the increasing water-vapor of the growing atmosphere reached the point of saturation, it took the liquid form and so became a contribution to the waters of the earth. Furthermore, it is probable that condensation occurred within the earth, long before the external atmosphere reached the point of saturation. Consequently, the waters of our globe probably had their origin underground in

the porous sections. As these waters increased, they rose to the surface and first appeared in the innumerable pits that had been caused by internal disturbances.

As the earth increased in size, volcanic activity set in. At first there was lacking sufficient compression in the central parts to produce the requisite heat. But once begun, this vulcanism increased and brought about changes in the rock formations that theoretically underlie the whole surface of the globe. These rocks now consist of former surface lava-flows and sediments that had been baked and fused to such a degree that the sandstone, gravels, clays and limestones were changed into bright and crystalline material in the form of gneiss, mica-schist, quarzite, horneblende-schist and marble, all of which go under the name of the "Archean Complex." At this point the hypothetical stages cease and observational geology [1] begins its work.

Plausible as the hypothesis may be, it is nevertheless replete with many unsolved problems. It raises many very difficult questions in celestial mechanics and will give a considerable amount of work to mathematical astronomers. There is

[1] See the geological time table on page 263.

no knowledge, for example, why the spiral nebulae glow with a steady and unchanging light, since there is no direct evidence that this light is produced either by heat or by electricity. Moreover, very few nebulae are known with certainty to be gaseous. Many of them do not show the presence of gases when scientifically examined. Again, the manner in which the stars are produced from the nebulae is not clearly understood. The spiral effect may not be concerned in the process, since in the Orion nebula which is not spiral, there is a direct relationship between stars and nebulae. Astronomers are also of the opinion, that, while the temperature of small particles in the nebulae may be very high, the mean temperature of the entire mass may be very low, and it has been shown that the appearance presented by the nebulae could be produced by widely separated luminous particles. In the face of many difficulties this planetesimal hypothesis may some day be replaced by another opinion based on more recent observations.

By comparing briefly the two principal hypotheses, the Nebular and the Planetesimal, the following stages of the earth are noted. These are based on the description given by Chamberlin and Salisbury.

Spiral Nebular Hypothesis

1) Nuclear or Nebular Stage.
The earth was originally a nebular knot, that acted as a nucleus, which grew to the present mass.

2) Atmosphereless Stage.
The solid nucleus was not massive enough to control the gaseous envelope.

3) First Volcanic Stage.
There was a contraction and a rearrangement of the material within the earth, thus causing gases to be produced. Vast quantities of gases were shot forth by volcanoes or escaped from lava-flows. These gases were given to the atmosphere.

4) Primordial Atmospheric Stage.
The earth was sufficiently large to hold the molecules of atmosperic material.

5) Initial hydrospheric Stage.
The water vapor reached the point of saturation in the atmosphere and fell to the earth. Water also came to the surface from the interior of the earth.

6) Climax of Volcanic Disturbance.
The compression within the earth became greater; the heat was so intense as to liquify the materials and send them to the exterior in large quantities. Other material was baked into crystalline rock.

Laplacian Ring Hypothesis

1) Astral, gaseous or nebular Stage.
There was a separation of the material of the earth from the original nebula to form a ring; then a concentration of the particles into a rotating gaseous spheroid.

2) Molten Stage.
The material of the gaseous mass condensed into a molten body which was surrounded by a hot vaporous atmosphere. Within the spheroid were all the elements of terrestrial Chemistry.

3) Solidifying Stage.
The molten mass began to solidify most probably at the centre on account of the pressure. At a later stage it hardened from the surface downwards. The two portions met or partially met giving the essential solidity to the whole.

4) First Volcanic Stage.
After the solidification of the crust, there was great volcanic activity, giving rise to lava flows from within. At the same time there were subordinated atmospheric and hydrospheric conditions produced by condensation and evaporation. This resulted in sedimentary deposits being interlaid with volcanic rock.

The objection might be raised that the slow processes described by hypotheses, like those mentioned, would exclude the Creator and would reduce the universe to a mere "fortuitous concourse of atoms." As put by one writer, "given a quantity of detached atoms cast into space, then mutual gravitation and the collision of fragments would give us the spangled heavens." Yet, if the results of scientific investigation can give rise to an hypothesis that seems reasonable, it would still redound to God's glory. Many facts in such a tentative explanation would still refer us to a First Cause. One would be the origin of the atoms and molecules with their original differences of matter and their varied powers of combination. The chemist knows of them and their characteristics, but Science will not tell him whence they came. Even the gravitational attraction cannot be accounted for unless as a mode of action given by an Almighty Power. If God permitted the various bodies of our solar system to be formed by secondary causes according to some plausible scientific hypothesis, He may by similar forces bring about conditions so "that the sun shall be darkened and the moon shall not give her light and the stars shall fall

from heaven and the powers of heaven shall be moved" (Matt. xxiv, 29). If such be His plans, then "at the end of the world the very great and very strong stars of heaven shall change their motions, appearances, influences and in consequence everything upon the earth shall be in perturbation, so that the world shall be shaken by unwonted movements, the sea shall overflow and the atmosphere shall be troubled with comets, thunderbolts, meteors, whirlwinds, and all things will seem to be utterly in confusion" (Cornelius à Lapide).

St. Peter in his second Epistle writes: "The heavens shall pass away with great violence, and the elements shall be melted with heat, and the earth and the works which are in it, shall be burnt up" (Chap iii. 10). In an ancient Sanscritic epic, the Mahabharata, there is also predicted the destruction of the world by fire. The following extract is of interest. "O king, towards the end of those thousands of years constituting the four Yugas, and when the lives of men become so short, a drought occurs extending for many years. And then O Lord of the earth! men and creatures endued with small strength and vitality, becoming hungry, die by thousands. And then

O Lord of men, seven blazing suns, appearing in the firmament, drink up all the waters of the earth that are in rivers and seas. And O Bull of the Bharata race, then also everything of the nature of wood or grass, that is wet or dry, is consumed and reduced to ashes," etc. With regard to the "seven blazing suns" there is also found a similar idea in the words of the Prophet Isaiah: "And the light of the moon shall be as the light of the sun and the light of the sun shall be sevenfold as the light of seven days: in the day when the Lord shall bind up the wound of his people and shall heal the stroke of their wound" (xxx, 26).

These are strange utterances, but they point to the belief that the world will experience the catastrophe of a great conflagration. How it is to come about is not known. There may be volcanic outbursts and disturbances, or, an outburst from the sun may cause the earth to burn up, at least everything on its surface could be reduced to ashes. In February, 1901, there occurred a violent outburst in Perseus. Small outbursts are daily taking place in the sun, as indicated by the red flames visible around that body at the time of a total eclipse or, at any time by means of the spectroscope, but they seem to be

unimportant and are not likely at any time to affect the earth. A great outburst could occur if the sun collided with some dark body in the heavens.

Astronomers have reason to believe that there are dark bodies in space, and if they exist, they would have their origin in cooled-down suns. These celestial objects, luminous at one time, by dissipating their energy in the form of radiant light and heat, would gradually become exhausted. When the cooling process of such a body had sufficiently advanced, the star would lose its light and roll through space as a cold and dark sphere. If the observations made by scientists are correct, then some of the variable stars already show this phase and perhaps in many cases the cold and dark stage may have actually been reached. Even the most up-to-date instruments would not be able to detect them as they show no light and would not be visible.

Our sun, in travelling through space with great velocity, carrying with it the earth and all its planets, might possibly come into collision with a dark body. Should this happen, an immense amount of heat and light would be produced and the prophetic utterances would be fulfilled.

However, as Our Lord says, "there would be

signs in the sun, and in the moon and in the stars" (Lk. xxi, 25), the coming of such a catastrophe would most likely be known, months and perhaps years beforehand. When the approaching dark body came within a certain distance of our sun, it would begin to shine by reflected light, as do the planets. If it were a body as large as our sun, it would first be detected far beyond the confines of the solar system. For some months and years its motion would be very slow owing to its great distance from the sun. Perhaps it would be mistaken for a "new" or "temporary star," or heralded as a distant comet. But in time examinations could be made to ascertain whether it was shining by reflected light or not.

By calculations, it is estimated that a dark body of the size of our sun, and possessing the density of our earth, could become visible by reflected light when at a distance of about 15,000 millions of miles from the sun. Assuming that this dark body were travelling through space at the same rate as the sun—about 11 miles a second,—and moving directly toward the sun, the time needed for the two bodies to come together can be approximately stated. If first visible at a distance of 15,000 millions of miles, this dark body

would require about 46 years to reach the orbit of Uranus or, rather, be at the same distance as Uranus. At the end of a year it would reach the distance of Jupiter. After that its rate of speed would be very rapid owing to the increased rate of attraction and in 51 days it would be at about the same distance from our sun that the earth occupies. If a direct collision were then to occur, the velocity would be so great that the sun and the dark sphere would meet in 8 days. Both bodies then would be reduced to a gaseous state within an hour, and the terrific heat produced would destroy not only the earth, but most likely all the planets of the solar system.

Even if the dark body did not strike the sun directly, it could in an elliptical orbit come close enough to it and still cause great disturbances due to tidal action. A large amount of extra heat would probably be developed. If the two bodies should merely graze each other, the enormous amount of heat produced would be sufficient to cause the earth's destruction.

These views, it is true, are only conjectural, but they show what could possibly occur by the operation of secondary causes which Almighty God has planned. As such, however, they enable us to understand to some extent the prophetic

words of Our Lord concerning that time when He shall be seen "coming in a cloud with great power and majesty" (Lk. xxi, 27). At the present moment no foreboding signs are detectable by man and it is but meet to consider the Work of Creation as now existing. We are prompted to exclaim with Gabriel in Goethe's "Faust":

"The sun-orb sings, in emulation
'Mid brother-spheres, his ancient round:
His path predestined through Creation
He ends with step of thunder-sound.
The Angels from his visage splendid
Draw power, whose measure none can say;
The lofty works, uncomprehended
Are bright as on the earliest day.
Though still by them uncomprehended
From these the angels draw their power,
And all thy works sublime and splendid.
Are bright as in Creation's hour."

CHAPTER IV

THE ORIGIN OF LIFE

LIFE! It is that certain "something" in animate creatures which is unfathomable. Its characteristics are noted, its presence is manifested, yet no satisfactory definition has been given. Some call it a principle, some call it a state, and others say it is a force. Surely the mind of man finds here a serious problem. Philosophers of old and of our day tell us there is a certain independent entity or vital principle which, uniting with the body, gives life, and separating from it, causes death. Professor Windle describes it as a "something over"—a vital force—which, according to the scholastic view is an "intrinsic principle of the living cell, constituting it living and differentiating it from non-living matter."

Bichat says it is the "sum-total of the functions which resist death." Herbert Spencer, after much thought, called it a "continuous adjustment of internal relations to external relations." Oliver Wendell Holmes describes life as "the

state of an organized being in which it maintains, or is capable of maintaining its structural integrity, by the constant interchange of elements with the surrounding media."

Definitions like the above could be multiplied, but they all prove to be vague and unsatisfactory and simply show that, from the days of the Greek philosophers down to the present, the nature of life has not been solved. Men are just as incapable of defining life as they are of telling us what electricity really is, although the latter apparently should be less enigmatical. The most satisfactory view that can be given regarding life, is to describe its essential notes. But the greater the endeavor to fathom it, the more mysterious it becomes.

Whatever views may be entertained respecting the actual nature of life, both philosophers and scientists in general affirm that at some period in the past history of our globe, the first germ of organic life made its appearance. This gives rise to another great question: How did the inert molecules at that first moment suddenly become endowed with vital power? In what manner was the first living protoplasm formed?

The Book of Genesis tells us not only that in the beginning God created heaven and earth, but

that He said: "Let the earth bring forth the green herb . . . let the waters bring forth the creeping creature having life . . . let the earth bring forth the living creature in its kind." True as these facts are, they do not seem sufficiently definite for some interpreters. These say that God is the Author of Life as the First Cause only. He seems to, or He could, have created the elements and then made them capable of combining under favorable conditions into some form of life. Others will have it that God created life directly and did not leave it to the operation of secondary causes.

In the laboratories, scientists with all equipment at their disposal, have not been able to solve the problem. Some of them have delved into the earth's most ancient history in order to obtain evidence. Even in the oldest rocks of the earth, where such information is sought, there appear evidences of life, telling us something of its characteristics and relative age, but nothing of its mode of origin. All that can be done with such facts is to build up a philosophical argument by means of which it is endeavored to arrive at the origin of life.

The opinions based on such argumentation may be placed in two categories. There is one

group of individuals, who are firmly convinced that life must have been produced spontaneously under physico-chemical action. No external intervention was necessary. Others, employing the same data, postulate some external influence, apart from the world, that brought about life. They hold that the facts of science lead to the conclusion that the spark of life began to exist upon this globe through the intervention of a Personal Creator. The question is one of vast importance, since on the one side the treatment of the subject leads to the existence of a Personal and acting God, whereas, on the other hand, the idea of a God becomes a chimaera.

The discussion of the problem of the origin of life has been an important one in the history of science and even in the present age, the controversy is renewed. In the days of old, Aristotle and other Greek philosophers and scientists were of the opinion that many animate objects, whose origin was unknown, were produced without parents by the force of inanimate matter. To them the mud of the rivers and decomposing animal and vegetable matter seemed capable of producing and organizing reptiles, fish, insects, worms and other small creatures. Aristotle *("Historia Animalium")* tells us that "Some

animals spring from parent animals according to their kind, whilst others grow spontaneously and not from kindred stock; and of these instances of spontaneous generation some come from putrefying earth or vegetable matter, as is the case with a number of insects." Again, "there is a species of mullet that grows spontaneously out of mud and sand." So also, he tells us that "eels proceed neither from pairing nor from eggs, but are derived from the so-called 'earth's entrails' that grow spontaneously in mud and humid ground" (Bk. I and VII).

The views of Aristotle were shared by the Roman poets, philosophers, and naturalists: Varro, Virgil, Lucretius, Ovid, and Pliny. Virgil devotes the fourth Georgic to the subject of bees and gives a receipt for replenishing them, when diminished or lost. He speaks of it as an art practised in Egypt. The process was to kill a young bullock by stopping up his nostrils. This would permit the skin to remain unbroken by any wound. After leaving the animal to putrefy within its hide,

"Behold a prodigy, for from within
The broken bowels and the bloated skin,
A buzzing sound of bees the ear alarms,
Straight issuing through the sides assembling swarms.

Dark as a cloud, they make a wheeling flight,
Then on a neighboring tree descending, light
Like a cluster of black grapes they show
And make a large dependence from the bough."
(Dryden's Translation.)

The observation was more or less correct, but wrongly interpreted. It escaped the notice of Virgil that there are certain flies, which very closely resemble bees and in their larval stage develop in decomposed matter. The so-called "bees" came from eggs that had been deposited by the flies.

Lucretius the poet-philosopher writes: "It remains therefore to believe that the earth must justly have obtained the name of mother, since from the earth all living creatures were born. And even now many animals spring forth from the earth, which are generated by means of moisture and the quickening heat of the sun" ("De Rerum Natura," Bk. V).

Due to the imperfect methods of scientific research, the spontaneous birth of certain individuals was an accepted view for many years. St. Augustine says: "Many small animals originate from unhealthy vapors, from evaporations from the earth or from corpses; some also from decayed woods, herbs and fruits. But God is the Creator

of all things." The Angelic Doctor does not exactly deny spontaneous generation, but severely reprimands Avicenna, who attributed it entirely to matter. Both St. Augustine and St. Thomas interpreted the fact in a manner different from the materialistic view of life. They asserted that if matter produces life, it is in virtue of a special power given by God.

For a long time after St. Thomas the theory of spontaneous generation was universally accepted and taught in the schools of the Old World. John Swan, the author of the "Speculum Mundi," declared that a dead horse breeds wasps, that from the body of an ass proceed bumble bees, while a mule produces hornets. Anyone desiring bees, must seek them in a dead calf, but with this condition, "if the west winde blow." To show the imperfect knowledge of the development of insects—that in all cases the connection was not perceived between egg, larva, pupa and mature form—his perplexity over the silk-worm may be cited. "Whether I may name it a worme or a flie, I cannot tell. For sometimes it is a worme, sometimes a flie and sometimes neither worme nor flie, but a little seed which the dying flies leave behinde them."

Father Athanasius Kircher, S. J., a famous

scholar of the seventeenth century, writes of a method of producing serpents by spontaneous generation that was given credence. "Take as many serpents as you like, dry them, cut them into small pieces, bury these in damp earth, water them freely with rain water, and leave the rest to the spring sun. After eight days, the whole will turn into little worms, which, fed with milk and earth, will at length become perfect serpents, and by procreation will multiply *ad infinitum.*" In 1644, Van Helmont, a Belgian doctor, gave a receipt for making bees. Others gave directions for obtaining mice from cheese or fish by the fermentation of substances.

But the spirit of correct scientific observation asserted itself and even in the seventeenth century many of the fables and strange views were dissipated. This was due principally to the efforts of Redi and Swammerdam. Redi was court-physician to the Grand Dukes of Tuscany, a member of the Accademia del Cimento of Florence, as well as of the Lincei, the earliest scientific academy founded at Rome, in 1603. Swammerdam was a prominent physician of Amsterdam.

In 1688, Francesco Redi, in a work entitled "Experiments on the Generation of Insects,"

proved that animals are born from the egg and not spontaneously. After having given a description of many experiments to establish his point, he writes: "Know then that, as it is true that meats, fish, and milk products kept in a protected place do not breed worms, it is likewise true that fruits and vegetables, raw and cooked, secured in the same way do not grow wormy; or, in the contrary case, left in an exposed place, will produce various insects of different species, according to the animals that have made deposits therein." He disproved a myth that the toad is generated from a duck putrefying on a refuse-heap. "Three experiments with this material brought no result, hence I was convinced that Porta, otherwise a most interesting and profound writer, had been too credulous. And Avicenna was none the less, for he would have it that women's hair, lain in a damp and sunny place, would turn into snakes. Now I believe that snakes are only generated by means of coition, and all other kinds of serpentine creation from rotten matter, or by processes mentioned by writers, are utterly false."

In another place he comments on the view of Pliny and others, "who relate that infinite kinds of animals are bred in the soil, in mud and

swamps, and in the bed of rivers," with particular reference to frogs. "But what causes me most amusement is the statement of Pliny that these same frogs, after a short life of six months, return suddenly to dust and mud, whence they again, on the approach of spring, become resuscitated to a new life.". . . "But these are all fables. Those animals that apparently were made of earth, had they been closely examined, it would have been evident that they were merely covered with mud: and though living things do arise in swamps and mudholes, it is because eggs have been first laid in those places."

"Land turtles also lay eggs and put them underground; and those that live in fresh or salt water lay eggs on the shore and cover them with sand, where they are acted upon by the sun's heat, and hatch; whence an inexperienced person might conclude that the little turtles were born directly from the earth, from which they are seen issuing."

By means of the above experiments and statements Redi strongly manifested his belief in the idea that there is no life without antecedent life —"*omne vivum ex vivo.*" For a long time the idea was accepted by the learned, and spontaneous generation fell into disrepute. But Redi's

victory was only temporary. That wonderful instrument, the microscope, was in the meantime being perfected, and it made known a new and undreamed of world of minute creatures called "animalculae." As the facts of propagation in all cases were not known, the old opinion of spontaneous generation again arose and found many adherents.

The eminent defenders now coming to the foreground were the English naturalist Needham and the French scholar Buffon. They asserted that, whatever views might be entertained of the origin of higher animals, there could be no doubt about the spontaneous production of certain of the lower animalculae from suitably prepared infusions of animal and vegetable matter. Abbate Spallanzani opposed these views, stating that the experiments undertaken were defective and therefore there was no justification for their conclusions. He gave as an example the dried ears of wheat. They appeared to be merely inert dust. But a drop of water placed on this "dust," even after a considerable period of time, was sufficient to reanimate it. Hence, life was not extinct, but only suspended. Furthermore, he showed that microscopic life, appearing in infusions, *e. g.*, beef tea, when exposed to the air, was due to

atmospheric germs. If the necessary precautions are taken against the admission of germs into such preparations, no animalcules whatsoever are developed.

Many scientists subsequently made a further study of the problem. Among them are to be mentioned Schultze, Schwann, Van Siebold, Leuckart, and Van Beneden. Despite their researches and the conclusion that life comes from pre-existing life, there were not wanting others who still adhered to spontaneous generation, or "abiogenesis," as it is also called. Such were the great chemists Berzelius and Liebig. They asked: "Was it certain that in the experiments which had hitherto been conducted, that the properties of the air, or the oxygen of the air or of the menstrua themselves, had not been essentially changed, and thus rendered them incompetent to give rise to the phenomena which they would exhibit in their natural and chemically unchanged condition?"

In 1858, M. Pouchet, professor of zoology at Rouen, fostered similar views. He claimed that he had seen microscopic animals come to life spontaneously in a fermentable liquid that had previously been rendered sterile, and into which was passed air deprived of germs. Many mem-

bers of the French Academy of Sciences, among them Claude Bernard, de Quatrefages, and Payen pointed out that sufficient precaution was not taken in the experiments. The dispute continued, and since it was an important problem, the Academy proposed that its examination be made the object of a prize. It was then that the great Pasteur entered upon the scene.

This prince of investigators took upon himself the burden of proving that, in every instance, life originates from antecedent life; that fermentation, putrefaction, and disease are the results of bacterial activity and the microbes themselves, as well as creatures of higher organization, are invariably produced by beings like themselves; that in all cases like proceeds from like, and consequently spontaneous generation is a chimaera. He instituted two series of experiments in order to prove the following facts: *1st,* a pure air, completely deprived of microbes, does not cause putrefaction in a fermentable but thoroughly sterilized liquid. *2nd,* pure air containing germs, will not necessarily putrify a fermentable liquid previously made sterile, because the microbes may not be sufficiently numerous.

Since the results of Pasteur's endeavors have proved to be of importance not only to the scien-

tist but also to mankind in general, it may not be out of place to consider some of the details.

(1) He showed that sterilized air would not cause a fermentable liquid free from germs to become putrid. At first he used a solution of sugar and albumen, then different broths, also blood, milk, etc. The different liquids were deprived of their germs by boiling, just as Pouchet had done, so that there would be no reason for accusing Pasteur of destroying the germinating powers of the preparations. He was soon able to show errors, against which Pouchet had not guarded himself. In such preparations high temperature does not affect all microbes alike. Sometimes they appear to be destroyed, but life is only suspended and latent, because certain germs have a covering which protects them from the heat for a long time. Especially was this the case in the preparations used by Pouchet and his adherents. Hence, it was not surprising that evidence of living forms appeared in Pouchet's experiments.

When Pasteur felt assured that the liquids were devoid of micro-organisms, he admitted perfectly pure air, deprived of those bacteria which are usually suspended in the atmosphere. The air reached the liquids by passing through a tube

of red-hot platinum. Thus, the microbes perished in the passage, but the composition of the air remained undisturbed. After some time, it was seen that the liquids showed no signs of life. Lest it be said that he disturbed the air by overheating, he then filtered air by causing it to pass through cotton-wool sterilized by heat and through asbestos previously calcined. The same result was obtained, namely, no evidence of living forms. To prove that the organisms came from the air, he took a few shreds of the cotton-wool and asbestos, which had checked the entrance of the microbes, placed the shreds in the liquid and directly there were evidences of life.

Again he took several flasks with zig-zag necks containing sterilized liquids and into some permitted the air to pass quickly and directly. Bacteria appeared in the cultures. Into the others he caused the air to travel slowly, with the result that all remained unaffected, because the microbes rested on the surface of the curved tubes. But when he brought these same preparations into direct contact with the air, germination set in at once.

(2) Pasteur also showed that natural air does not necessarily contaminate a liquid that has been sterilized. Pouchet asserted that air taken

from any spot desired, would act in the same manner upon such preparations. Pasteur denied this statement and gave proof of it after some time. He caused some fermentable liquids, in glass vessels, to come in contact with the air, some on the Jura and some on Mont Blanc. Many remained unchanged even after three or four years. The neck of one of the flasks happened to be broken accidentally in his laboratory, so that air was admitted. Inside of three days bacterial life was observed. Some fifty-six flasks containing liquids deprived of germs were opened in various places to let the air come in contact with them. Nineteen were exposed to the air of the amphitheatre of the Museum; nineteen were opened on the highest portions of the dome, and eighteen were taken to Bellevue and placed on a lawn under a group of poplar trees. Of the first nineteen, fourteen remained uncontaminated; of the second set, thirteen were not tainted, and at Bellevue all but one showed the greatest abundance of living forms, proving that the organisms were suspended in the air.

In England the experimentalist, Tyndall, undertook similar investigations, in order to verify the results of Pasteur, and arrived at the same conclusions. In fact, all the results of

scientific investigation point to the view that the air round about us carries numerous microbes, which can grow and multiply quickly in any nutritive preparation and bring about fermentation. The experiments also showed that as far as science goes there is no life, except that coming from preëxistent life. Tyndall remarks: "In experimental science there is no conclusion more certain than this. In the presence of these facts, it would be absolutely monstrous to affirm that these swarms of bacteria were spontaneously generated." Virchow, the celebrated founder of cellular pathology, tells us: "Never has a living being or even a living element—let us say a living cell—been found of which it could be predicated that it was the first of a species. Nor have any fossil remains ever been found of which it could ever be likely that they belonged to a being the first of its kind, or produced by spontaneous generation." Oscar Hertwig, the famous biologist, says: "Considering the state of natural science at this time, there seems but little prospect that any one engaged in scientific research will succeed in artificially producing even the simplest living organisms from lifeless material."

At the present moment Pasteur and his adherents are the victors in the controversy. But ac-

cording to Pouchet and Dr. Charlton Bastian of England, the question is only settled provisionally. They would agree with the statement of Huxley: "But expectation is permissible where belief is not; and if it were given me to look beyond the abyss of geologically recorded time to the still more remote period when the earth was passing through physical and chemical changes, which it can no more see again than a man can recall his infancy, I should expect to be a witness of the evolution of living protoplasm from nonliving matter." In his opinion, the solution would be found there and the scientist in the laboratory could then apply the formula.

Attempts have been made to show that the results of science are not conclusive. John B. Burke at Cambridge, England, by the action of radium on beef-bouillon produced objects which he called "radiobes." This was supposed to give evidence for spontaneous generation. The fact is, however, that the powdered radium produced some chemical changes. Radium can separate water into the gases, oxygen and hydrogen. It can also cause albumen to coagulate. So upon further experimentation, it was shown that the "radiobes" were little bubbles of gas, surrounded by a covering of coagulated albu-

men. The more the radium acted, the greater was the amount of bubbles produced, and this gave the appearance of a growing organism. Burke mentioned that the "radiobes" were seen to melt away in the water. What really happened was that the water, after a while, gradually removed the gelatine from the bubbles. Thus, no proof for the spontaneous production of life was given to science.

Although scientists in general agree that all living matter came from living matter, the question arises: Where did the first living matter come from? There was a time when life did begin on this earth, as scientific investigation shows. Geology assures us that the earliest rocks of the earth show a state of fusion at a temperature higher than the burning material of volcanos. In this intense heat, no life would be possible, and no germ could have offered resistance. Strangely enough, men like Fechner and Preyer would overcome the difficulty by having organic matter preceding inorganic, and say that the heavy metals in the rocks, once organic elements, are "signs of the dead primaeval gigantic organisms whose breath perhaps was glowing iron vapor, their blood molten metal, and their food perhaps the meteorites."

Certain authors have opined that the living forms may have fallen on the earth's surface as "dust" escaping into space during the passage of comets or shooting stars. This is not a satisfactory explanation because these stellar bodies must have received life from elsewhere. As Guenther remarks: "If we put life off to another planet, we have to ask how it was born there."

It seems to be a lamentable fact that scientific investigations do not give any proof for the spontaneous production of life. Professor Conn remarks: "It has been a disappointment to biologists to be obliged to admit that they find no evidence for the theory of spontaneous development, since at some period in the history of the world, life must have made its appearance for the first time. . . . The majority of biologists, however, believe it to be a logical necessity to assume that at some time in prehistoric ages, the first living thing appeared from a source which was not living. While accepting the fact that abiogenesis does not occur at the present day or under present conditions, biologists still claim that we have no means of knowing what may have occurred, under different conditions in earlier eras of the world's history. Thus the problem of the primal origin of living matter still remains un-

solved." Haeckel was more emphatic with his defence of this postulate when he wrote: "The living bodies *must* have been formed chemically at the cost of inorganic compounds; thus that complex substance *must* have appeared which we call protoplasm, which contains carbon and nitrogen and which is the material scene of all vital activities." And why *must* this have occurred? Because it is a matter of choosing between two possibilities: Natural Evolution or Supernatural Creation. He tells us: "If we reject monistic evolution, nothing remains but the irrational hypothesis of a miracle of supernatural creation." For him spontaneous generation *must* have taken place in order to avoid the idea of God.

But despite such rabid outbursts, we claim that the first spark of life came from a power superior to matter and to any of the forces prevalent in Nature. This is the only plausible and logical solution of the great problem. It was the result of that solemn *Fiat* in the first days of Creation. Reinke will tell us: "If we agree that living matter has at some time come from inorganic substances, then in my opinion, the Creation hypothesis is the only one which meets the necessities of Logic and of Causality and therewith answers to the needs of a prudent seeker after

nature. I take creation to mean that, at the beginning of time, when no living being of any sort moved on the surface of the earth, the first organisms came from preëxisting conditions of the earth's crust through forces that were not contained within inorganic matter, but worked on it from without, just as iron and brass are turned into machinery by forces that are not a property of these metals." Since scientists, in prudently considering the facts and in searching for the causes of phenomena, can trace everything to a Superior Intelligent Mind, there is but one opinion to be held: God gave the inert molecules the power to become animate according to His own plan. His noblest creature, man, realizes the greatness of this act, and since all power to bestow and deprive comes from God, we can say with Mordecai: "O Lord, Lord, almighty king, for all things are in thy power, and there is none who can resist thy will. . . . Thou hast made heaven and earth and all things that are under the scope of heaven. Thou art Lord of all, and there is none that can resist thy majesty" (Esther, xiii, 9-11).

CHAPTER V

POLLEN AND FLOWER

This earth of ours presents many objects and activities which, upon reflection, should lead one to the conclusion that they are marvels which proclaim the greatness and wisdom of the Creator. It was He who decreed that they should appear and function according to a mode of action which He prescribed. Even after careful study, they cannot be fully comprehended and may remain unexplained. In ordinary life the arrangement and movement of a watch engages one's attention. It is remarkable how the skill of man has been able to assemble many small parts so that they will interact and by means of their movement let us know the time of day. Especially may this be said of the very small time-pieces of modern times, which can be considered objects of wonder.

In Nature there exist structures and interactions of forces that are not as evident as the intricacies of a watch and very often they are not observed by persons, although in closest proxim-

ity. In many cases, it is only after attention has been drawn to such facts that an examination is undertaken. One phenomenon of this character is the formation of plant-seeds. These appear season after season, and what is more wonderful than in the case of the watch, they come regularly and excepting in a few instances, arise without the interference of man. Each particular kind of plant produces its characteristic seed, but no brand of watch can give rise to others. The reason of it all is that the Creator has given to these living plants the capabilities of producing their own kind. For He said: "Let the earth bring forth the green herb and such as may seed, and the fruit tree yielding fruit after its kind, which may have seed in itself upon the earth. And it was so done" (Genesis).

The phenomena connected with the first stages of seed formation deserve consideration. Ordinarily they may be viewed as a matter of course, but in reality they are of greatest significance and import.

The plant-world offers even to the casual observer, who may have very little knowledge of botanical science, a phenomenon that will prompt him to admire the foresight and arrangement of God. Indeed, there is scarcely any one whose

attention has not been attracted by the gay blossoms of plants, the yellowish powdery material that loosely clings to the stamen, the odor so delightful, and the humming and buzzing of many an insect. A little observation and reflection will show that all these elements, besides being things of beauty and poetry, have a purpose and redound to the wisdom of their Creator. From a biological point of view they all aid in that wonderful process known as pollination. A great many members of the plant kingdom depend on the seed for reproduction and multiplication. Yet, such a seed can never be produced, unless the pollen-grain be brought in some manner to the stigmas and eventually effect impregnation. The poet may sing: "Full many a flower is born to blush unseen and waste its sweetness on the desert air,." but the Almighty has arranged a place for it in Nature so that it, as well as its future offspring, may pay tribute to His glory.

In order that plants might fulfill the decree of their Maker "to increase and multiply," they employ various agencies to bring about the first stage necessary, namely, that of pollination. One of the great agents to accomplish this is the wind. Plants pollinated in this manner are very numerous and include cone bearing trees

(pine family), grasses, and sedges. Their pollen is dry and powdery in character and usually has a smooth surface, so that there is no tendency for the grains to cling together. Accordingly, they are readily shaken from the flowers and obtain a wide distribution by means of the wind. This pollen is yielded in enormous quantities and it has been estimated, for example, that a medium-sized plant of Indian-corn produces 50,000,000 pollen grains. Some of our textbooks state that pollen-carrying by the wind is a wasteful process. A great amount of pollen is produced and but a small portion reaches its destination. This does not bespeak waste. Almighty God had to supply a great abundance so that some at least would reach other plants. The remainder, which happens to fall to the earth, is not lost. After a process of decomposition it enriches the soil and forms nutritive material for other plants. There is no waste in the economy of Nature.

Remarkable is the fact that flowers which receive pollen by means of the wind, have a peculiar arrangement of their stigmas. Some of these are brush-like or richly branched as in the hazels, feathery as in most grasses and thread-

like as in Indian corn. This enables them to catch the dust-like flying pollen.

Another agent and an important one, destined by the Allwise Creator to aid in pollination, is the insect. This little creature is attracted to the plants by different factors. It darts from flower to flower to obtain food and instinctively chooses only such as contain what it needs. This food may be in the form of pollen or in the more luscious material: nectar. Many flowers produce nectar or honey in special glands called nectaries. Ordinarily it is called honey, but it is really nectar that has been swallowed by the insect (the bee) and by partial digestion has undergone slight chemical changes. The contents of the nectaries is a sweet sugary fluid, which at first is rather thick and syrupy, but subsequently becomes more diluted by the absorption of liquid from beneath. A good example of the process would be the following: If two hollows were made in an unpeeled potato and one of them filled with powdered sugar, after about an hour, this one would be full of syrup, which might even overflow. The other hollow will be dry and empty. The sugar has drawn water out of the potato. In this way, plants produce nectar

and employ water that has been absorbed from the soil. If nectaries happen to be at the base of the stamens, the nectar absorbs the moisture from these pollen-bearing structures, and causes them to dry up, so that the pollen itself becomes exposed. Such stamens have been found to be dried up even though the atmosphere had been saturated with moisture.

Not all flowers produce nectar. A limited number offer no other food but pollen. Yet, here too provision is made, since such flowers usually possess a large number of pollen-bearing structures, so that sufficient grains both for pollination and food are present. As a rule insects take a certain amount of pollen as food even from flowers that produce nectar.

Many flowers exhibit devices for protecting nectar and pollen from the injurious effects of dew or rain. The simplest method is for the pollen-bearing portion to close up more or less completely, when the air becomes damp. In other cases the entire flower closes, in order to shield the honey and pollen. The same end is obtained by the hanging position of many flowers as, for example, in the lily of the valley.

The insects find the various plants by means of the colors of their flowers. The essential requi-

site of floral color is that it be conspicuous and produce quite a contrast with the general color of the plant, which is usually green. Accordingly, white, yellow and red are the commonest colors in flowers that nestle among foliage. The less contrasted blue is rather more common in flowers that stand by themselves, whether singly or in long terminal clusters. Another point of interest is that certain insects show a preference for certain colors, and flowers possessing such colors are usually of a size and construction better fitted to the visits of these particular insects. Hence, most of the small regular flowers are yellow and white and are visited by a great variety of small insects, especially flies, blue flowers by bees and red often by butterflies. White flowers of specialized kinds, like orchids, are preferred by moths, which happen to be the only insects with sucking organs of sufficient length to reach the bottom of the unusually long nectar-bearing tubes.

The white color is found to distinguish most of the flowers that bloom at dusk, a color therefore most conspicuous in darkness. It so happens that such white flowers are visited by moths, which are chiefly night-flying in habit.

Brilliant colors are found in flowers that grow

in rather inhospitable places, such as the Arctic shores, the desert wastes or the Alpine heights. The Alpine flowers are famous for their beautiful coloration. In these places, insects are scarce and the extra brilliancy is designed to attract them.

A good many flowers display a variety of color, which consists chiefly of definite spots or lines quite different in hue from the ground color of the flower as a whole, as in forget-me-nots, pansies, and nasturtiums. They are said to act as honey guides, in that they indicate the position of the nectar. The general color attracts the insect to the flowers from a distance, and these markings then show the place to probe for nectar. They also bring the insect into the position where it can best leave pollen or receive an additional supply.

There is still another form of allurement. The poet sings "that many a flower wastes its sweetness on the desert air." This does not agree with facts. The color of flowers is sometimes aided and often replaced by the odor issuing from them. It has even been claimed in late years that insects are guided to flowers much more by the odors than by the colors, and that many odors are hardly, or, not at all perceptible by us.

But, whatever the case may be, the odors assist the colors, especially where color alone cannot be made sufficiently conspicuous. This would hold true of night-blooming flowers in which sweet odor and white color are common. The odor also aids flowers that bloom in very inconspicuous positions—close to the ground or among leaves in the shade, as seen in the Mayflower, Virginia creeper, and Dutchman's pipe. While most odors happen to be pleasing to us, there are some (skunk cabbage) that are obnoxious. Yet they have their lovers among the insects and are doubtless very delightful to them.

It is an interesting fact that many flowers give off their scent mainly at the time of the day when the insects which pollinate them are most active. Some kinds of tobacco and honeysuckles, petunias and catchflies, have very little odor by day, but are quite fragrant at night, when the moths which pollinate them are on the wing. On the other hand, many plants of the pea family, which are pollinated by day-flying bees and butterflies, give off their fragrance mostly by day, and especially in strong sunshine.

The insects most frequently acting as pollinating agents, are various types of bees and humble bees, butterflies, moths and many kinds of flies

and beetles. All of them, except the beetles, possess a special sucking-organ arising from the underside of the head and of different lengths. In flies they are short, whereas in butterflies and moths they are exceptionally long and are coiled up when not in use. Due to the different positions taken by the insects upon the flowers, diverse parts of the body may become dusted with pollen. These parts are often covered with minute hairs, to which the pollen readily clings. In this manner, the pollen taken from one flower will most likely be rubbed against the stigma of another flower, which the insect visits, thereby bringing about pollination.

A great many flowers like the buttercup, poppy, rose and others having radial symmetry, are visited by many sorts of insects from flies to bees. But flowers having bilateral symmetry, *e. g.*, violets, mints, wild balsam and a goodly number of the pea family are frequented only by insects that can reach the nectar or pollen, or both. In violets, the pollen is abundant but it is concealed and the nectar is at some depth. Both elements are easily reached by the tongues of bees but not by small insects. In the snapdragon, the flower closes up firmly and no small insect can enter. Bees, however, can overcome

the elasticity of the hinge at the junction of the lips and gain entrance.

Some plants depend on a single kind of insect for pollination and therefore cannot set seeds, if that species of insect is not at hand to carry pollen. The fig-tree may bear large juicy fruit without visits from insects, but it cannot produce seed unless pollinated by a small species of wasp. The yuccas, lily-like plants, that grow in desert or semi-desert regions, have flowers that are white or nearly so. Pollination is impossible in one species without the aid of a small female moth. During the day the moth remains at rest within the flower. At dusk, it crawls to the pollen-bearing portions where it collects a considerable amount of the pollen and holds it by means of spinous appendages of the head. Frequently the mass is three times the size of the head. Then the moth crawls about toward the structure containing the ovules. It pierces the soft ovary wall with the sharp tip of its egg-depositing apparatus and inserts one of its eggs. After this process, the creature uncoils the appendages holding the pollen and with its tongue vigorously thrusts the pollen-grains into the opening of the ovary for several seconds. In this manner, the insect has brought about pollination and has also

secured food for the little grub that will come from the egg it deposited. The larval form later bores its way to the exterior, drops to the earth and makes a cocoon of silk a few inches under ground. It is probable that it does not assume the form of a perfect insect until the next blooming time of the yuccas. The plant is pollinated by its own reproductive elements, a fact which does not obtain in all cases.

Another example of a flower specialized for insect visitors is the Dutchman's pipe. It resembles the pipe that the Hollander smokes, having a curved lower part and two upward pointing lobes, one being the hooded exit, the other containing the pistils and stamens. A fly laden with pollen enters and falls to the bottom of the curve. It tries to crawl to the surface but the inner wall of the flower is so smooth that its endeavors prove futile. Then it flies from one side to the other and in so doing dusts the stigma with its pollen-coated body. The fly remains entrapped for a day or two and in the meantime the stamens ripen. In darting back and forth the fly raises a perfect dust-storm of pollen which finally lodges on its body. Meanwhile also, the flower begins to wither and the insect climbs along the now roughened sides to the exterior and

brings the pollen to another flower. Here is to be noticed a wonderful arrangement to prevent self-pollination, namely the stigmas have ripened first and received pollen from the insect, and only later do the stamens become mature, so that the fly may carry their pollen elsewhere.

The greater part of pollination is performed by insects, but they are not the only animals that attend to this function. There are certain birds that seek nectar, and the most familiar in our own country is the humming-bird. In Asia and Africa the sun-birds are most efficient. The flowers pollinated by them are large and showy, many of them being scarlet or deep orange. Some of the most familiar flowers visited by birds are the trumpet-creepers, the scarlet salvias, century plant, cotton, evening primrose, oleander, and certain species of tobacco. Among other animals that effect pollination are snails. They are not abundant in this country and therefore not important agents. In some countries of the Old World they swarm in almost countless numbers on the foliage and flowers of many species of plants related to our jack-in-the-pulpit and dragon root. They are said to visit some of these plants for the soft tissue that grows abundantly among the blossoms. In doing so, they

transfer pollen from one plant to another.

Here, finally, might be mentioned the fact that plants in some instances display wonderful provision to keep away unwelcome guests, the food being reserved for animals that can be of assistance in the process of pollination. All other forms would simply feed on the honey and be of no benefit to the plant. One mode of protection has already been indicated, namely, that the pollen and honey are so situated as to be accessible only to desired animals. Another method is similar to that employed by gardeners, in order to keep away snails, caterpillars, centipedes, and other creeping forms. The horticulturist places the pot containing the plant upon another low pot inverted in a shallow dish of water. The plant becomes isolated and the creeping forms cannot approach. The crowns of young trees are at times protected by tying a sticky cloth or cotton around the stem, or, painting the bark with bird lime or other mucilaginous material. By means of this arrangement, the animals in creeping along become entrapped. Again, belts of spiny branches are attached to stems of trees, so that progress is impossible for the sensitive caterpillars, snails, and slugs.

What man does by artificial means, that Na-

ture is able to provide for various plants. There are many water plants and bog plants which are protected by their isolation. The water-lilies, bladderwort, water soldier, and others can only be visited by flies and bees that come through the air for their food and thereby aid in pollination. All the creeping forms are checked by the water. Some plants have their leaves so constructed that they contain small amounts of water, and crawling forms in search of honey are destroyed in such basins.

Better still is the production of viscous substances by some plants. Ants in crawling toward floral portions of certain plants, touch tensely gorged cells with the claws of their feet. These cells then burst readily and a milky substance is exuded. This covers the feet and abdomen of the ant. In self defence, the insect bites at the substance and as a result covers its head with it. The ant struggles to free itself, but only causes more and more cells to be irritated and ruptured. Some of the ants manage to escape and fall to the ground, but many an intruder is simply glued in the material and eventually succumbs.

The plant called catch-fly by its very name suggests some such protection. The lower portion of the stem is green and shows no sticky

coating. But in the upper section, in the immediate neighborhood of the flower, is secreted a viscid substance which prevents the approach of small insects. In some other plants, the entire foliage is sticky, and frequently the dead bodies of insects, who ventured upon them, may be found adhering to the leaves.

The flowers of some plants have a waxy coating, making it difficult for creeping forms to proceed. Certain kinds of willows depend on the bee for pollination and the honey is reserved for this insect. Ants and other crawlers in attempting to reach the honey, slip on this waxy coat, lose their footing and fall to the ground.

Other flowers, not arranged for the visits of snails or slugs, display spines, prickles, and stiff bristles, and toward these the soft-bodied animals are very sensitive. It is noticed that plants possessing spiny structures, show an abundance of them near the flowering structures. Besides keeping away the undesired visitors, they also act as "path finders" for the useful honey-sucking insect. They place the insect in the best position for dislodging pollen grains upon the stigmas.

Plants like the pinks produce a good amount of honey, which is reserved for insects that visit the flower from above, where the stamens and

stigmas appear. Bees and humble bees at times endeavor to obtain honey by simply biting through the delicate covering of the honey receptacle. This cannot occur in the pinks, which have tough overlapping scales, like the shingles on a house, around the receptacle. Not even the strongest humble bee can pierce this guarded portion. The only alternative is to obtain the honey from above and so aid in pollination.

The ants in general are not good pollinating agents because they cannot transfer the pollen grains with sufficient rapidity from flower to flower. For that reason, they are excluded from many a honey-producing plant. However, they do render service to certain plants by guarding and protecting the flower. Some European forms of the thistle group, whilst bearing the buds of future flowers, are liable to the attacks of devouring beetles that bite big holes into the buds and destroy the undeveloped flowers and the leaves which usually surround them. To ward off such attacks, a group of ants is employed. During the development of the flowering portion, honey escapes through the scaly covering of the bud. As it is produced in large quantities, the ants are attracted and they remain on the unopened bud as long as the delicacy is furnished

to them. Should a beetle appear in the neighborhood, the ants assume a menacing position. They hold on to the scales of the bud with the last pair of legs and present the forelegs, abdomen and powerful jaws to the enemy. They remain in this attitude until the beetle withdraws. Should the beetle come too near, then the ants squirt some formic acid toward it. When the enemy has left, the ants quietly continue to feed on the honey. It is significant that these creatures do not fight among themselves, even though fifteen may be present on one bud at the same time. As soon as the flowers begin to unfold, the production of honey becomes less and ultimately ceases altogether. The beetles will then no longer seek the tender contents of the original bud, nor do the ants remain as guardians: they leave and go in search of other, younger flower-heads.

These facts show wonderful arrangements in the plant-world, in order that seeds, so necessary for multiplication and reproduction, may be produced. Many present-day writers would have us believe that all these phenomena are the results of Chance: that in the beginning there was a fortuitous intermingling of atoms, which in course of time gave rise to the varied forms now

existing; that owing to some "force" in Nature these plants were able to produce structures and processes that would prove beneficial in that peculiar "Struggle for Existence." Darwin says: "Hence we may conclude that, if insects had not been developed upon the earth, our plants would not have been decked with beautiful flowers, but would have produced only such poor flowers as we see on our fir, oak, nut and ash trees, on grasses, docks, and nettles, which are all fertilized through the agency of the winds." It must be remembered that the gay flowers are not independent parts, but are correlated with a vast number of other properties of these plants, with which the insects could have nothing to do. The implication that the insects are the cause of the gay flowers, does not explain the case. Similarly it could be argued that the honey associated with the gay flowers was the cause of the suctatorial proboscis of the insects.

Others again will concede that there is present here a certain law and arrangement, but they would trace it all to a cause that is unknowable. Yet any one considering these facts with unprejudiced mind can recognize a plan and arrangement instituted by a Superior Intelligence. This Superior Mind, Our Creator, though invisible

is not unknowable. "For such is the energy of the true Godhead, that it cannot be altogether and utterly hidden from any rational creature. For with the exception of a few in whom nature has become outrageously depraved, the whole race of man acknowledges God as the maker of this world" (St. Aug., "Tract. in Joa.," 106, n. 4). His Wisdom "reacheth from end to end mightily and ordereth all things sweetly" (Wisd. viii, 1). Hence, with the Psalmist, the fair-minded person can exclaim: "The eyes of all hope in Thee, O Lord: and Thou givest them meat in due season. Thou openest Thy hand and fillest with blessing every living creature" (Ps. cxliv, 15-16). In truth, "He made the little and the great and He hath equally cared for all (Wisd. vi, 8).

CHAPTER VI

DISTRIBUTION OF PLANTS AND SEEDS

FROM the moment that Almighty God manifested His will by uttering that solemn *Fiat* on the third day of Creation, there have gradually appeared upon this earth of ours an abundance and variety of vegetation. By His decree the earth was to bring forth the green herb and the tree, each producing seed according to its kind. It was also according to His design that plant-forms were to appear from season to season and be a source of admiration and benefit to mankind.

The many forms of the plant kingdom were not to be confined to one restricted area, the seeds were not to fall directly downward from the parental form and germinate in closest proximity. It was the Will of Our Creator that they be distributed to other parts, in order that favorable soil and uncrowded conditions be furnished for their development.

The processes connected with the formation

of even the smallest seed are interesting and complex and show the forethought and arrangement of some one who is allwise and supreme in power. Similarly, the work of God, as seen in the distribution of plants and seeds, prompts us to express our deepest feelings of wonder and admiration. The facts given in the following pages will show how this Great Sower went out to sow His seed, by noting, in the first place, a few examples of plants that came into new surroundings, and then the manner of their dispersal.

From time to time we may be made cognizant of the fact that changes of vegetation have been brought about in certain areas where forest fires had occurred. Plants and trees of different species from those formerly growing there sprang up. The writer of these pages had occasion to witness this fact while visiting the inland-sections of Martha's Vineyard, where after a great forest fire, numerous berry bushes made their appearance. Investigations have shown that a certain cress, which grows in meadows, swamps, streams and ditches has been found everywhere in Europe, excepting the Arctic portions, in Algiers, Abyssinia, India, Ceylon, in Northern Asia, on the Islands of the Pacific, on Mauritius, in Eastern

and Western North America to the Arctic Ocean, in Columbia, Patagonia, Buenas Ayres, Chili and some other regions of South America. The American plant, water-thyme, has for its habitat the rivers, from Canada to the Mississippi. It was first noticed in Ireland, in 1836, just after some North American water plants were transported to that country. That very same year, the body of water in which it happened to thrive, was filled with this plant. Five years later, it appeared in several lakes of Scotland and England. It travelled along the canal system of Central England and by its rapid growth checked fishing, boating, and the opening and closing of the sluices. It even stopped the flow of water, so that floods occurred. This plant did not reach the Continent for a long time, not until a botanist in Berlin applied for samples of it from England, in 1854. Gradually it was found spreading to different centres of Northern Germany. In 1858 it was found in Belgium. Data are not at hand, but in the meantime it may have found a footing in other parts of Europe.

These examples show that plants have found new homes and that some of them at least, are widely distributed. Naturally, one is curious to

know how these plants were able to invade new territory and what means God placed at their disposal to enable them to accomplish this end.

The modes of distribution are varied. Some plants have an independent locomotion and this power is well developed in the simpler forms that lack the firm cellulose covering. The slime-moulds, for example, creep along. They are gelatinous masses that are sometimes seen in damp places, on decaying wood, on neglected flower pots and they creep along by a simple method of advancing a stream of their substance in one constant direction.

Other plants, or, rather their reproductive spores, can swim freely in the water, a characteristic possessed by sea-weeds. The motion is brought about by innumerable tiny hairs, that beat the water more vigorously in one direction than the other, or they move by means of outgrowths that appear like tails or whips, which they pull behind them. Others, again, living in the water, make use of the vibration of their rod-like bodies. Their movement is similar to that of a piece of flexible steel that is shot through the air after having been bent between the thumb and fore finger and then quickly released. Certain plants possess a soft texture and are able to send

out runners or stems. If the stems are sent out horizontally, so as to touch the ground, their tips will strike roots and send up a new shoot. Hence, new plants arise at some distance from the parent, from which they will later be cut loose by the death of the intermediate stem. The strawberry plant illustrates this very well. By means of the runners and new shoots which appear, a single plant may give rise to numerous daughter plants during the course of one summer. Another plant, the anemone, seen in forests and meadows in spring, has a horizontal root bearing three buds at the tip. One of these develops into a flower, the second into leaves and the third in the following year produces a horizontal root to one side. The old root at the opposite end dies off. In this way the plant creeps along gradually and after a number of years is found in an entirely different locality.

Certain mushrooms have underground equivalents of roots that radiate horizontally. They may be compared to a wagon wheel lying on the ground. The hub would represent the plant, the spokes the streamers radiating from it. These send up new mushrooms at so regular a distance from the parent as to form a very prominent ring, to which has been given the name "fairy-ring."

The briars and blackberries have very slender stems capable of curving over and bringing their tips to the ground. There they strike root and produce other shrubs. Some tropical fig-trees frequently send out aerial roots from their trunks and branches. These roots bend over and upon reaching the ground, become fastened and give rise to a new trunk. By this process one tree can become the progenitor of numerous younger shoots, which continue the same function, long after the original tree has been destroyed.

In other plants the main stem creeps on, or just under, the ground, striking root or sending up shoots as it goes, thus spreading its own growths to new places. The grasses have creeping stems that run and branch so freely and interlock so closely that they form the dense mats, we call turf. Solomon's seal grows onward year after year. The old parts die behind as the new parts are developed in front. However, by means of runners and the creeping of the roots, plants are enabled to spread to a limited extent only. For that reason the above cited methods have been called "supplementary," since these plants possess other means that afford them a much wider distribution.

Plants in their embryonic stage as seeds are

small and can be readily transported from place to place by various modes of dissemination. In certain species the different layers of the seed-pod dry up to an unequal extent during ripening, so that a tension is created which leads, at the slightest touch, to a sudden explosive opening of the fruit. The seeds, which lie loosely within, are then hurled to distances of several feet. This happens in the pansy and the violet, the sides of whose ripening pods dry and split during the hot weather. The sides come to press harder and harder upon the smooth seeds held in the angle between them, until finally, the seeds are shot out of the pods in the same manner that a smooth bean or nut can be shot from between tightly pressed fingers. The pod of the sweet pea when ripening, dries and splits into two valves. This often occurs suddenly and with some violence, and as the valves twist at the same time, the seeds are flung a little distance away.

In the poppy and the snapdragon, the seeds lie loosely in open-topped capsules at the ends of long, stiff, elastic stalks. When the stalks are shaken by strong winds or by the impact of animals, the seeds are thrown out by the movement, especially by the jerky recoil, which acts similar to a catapult. The exit of the seeds from

the pods lies along smooth grooves so placed, as to guide the seeds at an angle best suited for their flight to a distance.

Instead of the slinging device, some fruits in ripening, do not dry up but remain green and become very turgid, that is, a pressure is developed by tensely-gorged cells against the lines of a weaker sort. The least touch would cause an explosive rupture of the fruit and the seeds are shot out. This happens in the touch-me-not, a common wild plant. Fabre mentions the peculiar action of a plant called the squirting cucumber. The entire pulpy mass inside the firm-skinned fruit, ripens so turgidly that the pulp and seeds together are shot out to a distance, when an outlet is made by breaking the fruit away from the stem. All these devices permit various plants to spread their seeds to various distances.

A method very useful to the distribution of plants, is that of waftage by the winds. These winds are present everywhere and occur in all degrees from the violent gales that create disturbances for hundreds of miles down to the gentle breeze found only in limited regions. Here must also be included the upward currents of the air which rise over heated places in summer, to

heights where the winds and breezes prevail. The seeds carried by the wind are constructed or so provided with devices that they expose a great surface in proportion to their weight. The simplest forms consist of minute and light seeds, which in the case of the orchids are nothing but a powdery mass, like pollen. Other plants propagate by light seeds of somewhat larger size that are capable of being carried a considerable distance. They are attached to the plant in such a manner as to be easily shaken off. This occurs in the primrose where the stalk is swayed and the seed scattered by the wind. Such devices are known as "Censer Mechanisms" because the dispersal of the seeds depends upon the swaying movement that the winds produce.

The cone-bearing trees, birches, elms, maples and ash have seeds provided with lengthened wings. The manner in which these seeds are blown about on some of our streets proves the efficiency of this device. Some members of the pea family have the pods greatly swollen in the form of bladders and in these the seeds are to be found. Thousands of these seeds may be destroyed along the journey or fall on unfavorable ground. However the decomposed material can again be taken aloft by the wind and deposited in

places where it enriches the soil. Many of them, though, fall on good ground and so form a *terminus a quo* for future distribution.

Another splendid method is the provision of long soft hairs or plumes. The seeds possessing this construction are numerous. By means of the tufts or plumes the seeds can float in the air and catch the slightest breeze. Such seeds and fruits are often carried great distances, and the kinds of plants that bear them are found widely distributed over the earth. Plumed seeds with tufts of fine silky hairs are present in the poplars, willows, and willow-herbs. The cotton-seed develops hairs of such number and length that they serve not only to spread it afar under the action of the wind, but also prove of great value to man, since they yield him the fibre for the commonest of all his clothing materials.

In the dandelion there is found a "parachute plume." The seed is at one end of a stalk and the plume at the other. The plumes spread out more or less horizontally when the air is dry but close together vertically in dampness. Being very light, the seed can be lifted over the tops of trees and transported great distances under favorable conditions. It falls to the ground with the

advent of rainy weather, during which time it is likely to be washed into the soil. The dandelion and its related forms constitute the largest and most widely distributed of all existent plant families.

A little observation will show that plants whose seeds are winged, in general, belong to trees, whilst the plumed variety belong to herbs. This is a remarkable provision. The plumes are better lifting devices than are the wings. The extra height of the trees and their greater exposure to wind, give the winged seeds a start which is ample to transport them to considerable distances. Moreover, some seeds are so contructed that they take a serpentine or spiral course through the air, thus giving the wind a longer action on them.

Not only seeds but other parts of plants capable of growth are also carried along by the winds. Some varieties living in open dry places, at times, roll their branches inwards to form a sort of ball. In this state, they may be easily blown from their anchorage and sent rolling across the plains to take root again in new places. These plants are called "tumble weeds" and are characteristic of the prairies and plains. The

Russian thistle, the rose of Jericho, and the Resurrection plant of the Southwest, furnish good examples.

In the world of Nature provisions are also made for various seeds that fall in odd places, after being borne along by the wind. As examples, church-towers and the gutters of old ruins might be mentioned. The wind carries particles of dust, many of which lodge in such places. The seeds of mosses carried by the wind then alight there or are stopped abruptly. When the mosses die, a humus is formed and in time the seeds of grasses are embedded there. As time goes on, even small bushes may make their appearance, in a similar manner. Nature will make use of any spot, where a small amount of dust or soil can find a place. She soon enhances it with the green of her vegetation.

The wind currents are very important in mountainous regions. Fields of snow and hard smooth rock offer no place for the germination of the seeds. Accordingly only odd patches show signs of vegetation and the wind is the means of bringing it there. Creeping plants and the ordinary pod arrangement are of no avail. The writer witnessed this phenomenon in the Canyon of the Yellowstone National Park and in the

Grand Canyon in Arizona. On ledges of apparently bare rock and on somewhat steep inclines, pine-trees are growing either singly or in small groups. The mountain-climber would have difficulty in reaching some of the places, but the pine-seeds were carried there by the winds. A similar condition was observed in Walnut Canyon, Arizona, where the ruins of cliff-dwellings are to be seen about three hundred feet above the ravine. The pines are located on different shelves of rock one above the other as if some one had planted them there methodically. On the volcanic fields at the foot of the extinct Sunset Mountain, about twenty miles away, there were seen numerous pine-trees which trace their origin in that locality to seed dispersal. However, the roots do not extend to any great distance below the surface, but lie in a horizontal plane, sometimes even above ground, in order to obtain moisture and the requisite materials in solution. This condition permits the trees to grow for a number of years, but then they may be blown over by strong winds or else suffer premature decay for lack of nourishment. This fact may again give the impression of a wasteful process in Nature. But it need only be mentioned that the various ingredients of the disin-

tegrated trees will be scattered over those fields of lava and volcanic cinders and in time will produce a better soil for vegetation.

Another agency instrumental in distributing plants is water. It may be in the form of streams flowing from the hills into the valleys, of rivers traversing extensive regions, or again of ocean currents that flow into far distant parts. Seeds may fall directly into mountain streams or rivers, or be carried thither by the rains and floods. They may be conveyed great distances and eventually cast upon the bank where their presence will be noticed in due season. Chamisso found different forms of mountain flowers in the coastal sections of Chili. Later, another botanist found similar plants in the highest sections of the Chilean Cordilleras, near the eternal snows. Apparently the seeds of these plants were carried downwards by the streams and found a favorable place along the coast.

The largest rivers of the earth, such as the Amazon, the Orinoco, and the Mississippi, tear large portions of soil away from the shores and transport them to other places. These portions appear like swimming islands and bear plants, bushes, and even small trees upon them. The entire La Plata at times has the appearance of a

large meadow with various forms of vegetation.

In the smaller bodies of water, some plants secure transport by living in the water. Water cresses are only lightly attached and are readily moved to new places. Some plants have floating seeds, as for example, the white water lily. These seeds have a spongy covering filled with air. When the seeds escape from the fruit, which ripens and opens under water, they float to the top and sink when the water has soaked in and displaced the air. The yellow water lily has spongy fruits, that float about and only when decaying do they permit the seeds to escape. The African lotus has a great top-shaped and air filled receptacle. This forms a very effective float for the seeds that are dropped here and there, as it goes. Most of the wind-scattered seeds are so light that they can float upon the water and obtain a still wider transportation.

The waters of the ocean are well worth considering. Scarcely has a new coral island made its appearance above the waters of the South Seas, when vegetation appears. The waves and ocean currents bring the plants to new homes. The Galapagos Islands are about 120 geographical miles distant from the western shores of tropical America and about 600 miles from the near-

est islands of the South Seas. Darwin in his famous expedition noticed that of 265 species of plants found on these islands, 144 were related to species of South America. Since the Galapagos were almost uninhabited, or only settled at a late date, it was difficult for a long time to solve the problem as to the origin of these 144 plants on the ten islands. Human beings could not have transported them, nor birds, as there were no types common to both the islands and the mainland. Even the wind, blowing northwest from Peru, did not offer a satisfactory explanation. As time went on, it was noticed that the plants common to the islands and to Peru, also grew in other parts of the western coast of South America. It was also observed that besides the ocean currents running from Peru towards the South Pole, there was a local current running from Panama Bay southwestward to the Galapagos Islands. Since the plants in question grew on the islands and also in Panama and the plants strictly belonging to the Galapagos were not found on the mainland, it was concluded that the plants came from Panama and were transported to the islands by the current.

The oceans also carry fruits and even plants from island to island and from mainland to main-

land. Certain plants have been brought from the West Indies to Ireland by way of the Gulf Stream. The greatest distribution occurs when plants can go from island to island, as a long journey by water proves harmful and causes the seed to lose its germinating powers. The flora of the Society Islands, as an example, shows greater resemblance to that of India than to that of South America, although the latter land is nearer. The reason is that the various islands form stepping stones from India to the Society Islands, whereas no land exists east of them towards South America.

There is one plant whose seed has been wonderfully provided for, so that it can be carried considerable distances, namely the cocoanut palm. The cocoanut is a fruit that has a fibrous layer and a hard inner shell, within which the true seed is enclosed. The fibrous portion is air-filled and is covered by a water-tight skin. This arrangement enables the fruits to float on the waters for weeks, and at times they are carried from island to island many hundred miles apart. So marvellous is the power of this husk to resist deterioration in the water, that ropes and cords are made from it and employed where resistance to decay in salt water is particularly needed. It

might not be out of place to mention that the palm trees are valuable to the inhabitants of various places and are utilized in many ways. From the bark of the tree, rope and matting are made; from the leaves, hats and palm-leaf fans; from the fibre of the nut, rough clothing, sails, cordage and fishing nets; from the sap, sugar; from the green fruit, milk; from the ripe fruit, food; from the kernel, rich cocoanut oil for lamps and the hair. Surely the Almighty could not have provided more wisely and abundantly.

As a last example of a plant affected by the water, the seed of the mangrove tree may be cited. This is a peculiar plant that grows in the muddy regions of the Tropics. Its seed shows a wonderful arrangement. It begins to germinate while still clinging to the tree, and grows into the shape of a spindle. When it drops from the tree, it penetrates the mud with its pointed end. Even if the water should rise one half of a foot above it, the seed will not be removed. It strikes root quickly and from day to day fastens itself more firmly, so that in a short time it can withstand the strongest surge.

A distribution of plants is also effected by means of animals which Nature has pressed into her service. To facilitate matters, she has pro-

vided seeds with special devices so that the animals, always roaming among plants for shelter and food, become the unsuspecting agents of distribution. These seeds have hooks and other arrangements suitable for attachment to fur and feathers. The close-clinging burdock is a sample well known to all who may have gone through the fields in Autumn. Striking examples are furnished by plants of the Great Plains. There, large animals are in abundance and the unicorn plant catches in the tails of the horses. In South Africa there is the grappling plant, which entangles itself in the fur of the lions.

The spiny clotbur has seeds provided with little spines, as its name suggests, and its habitat is in Southern Russia, from whence it spread over the greater part of Europe. In 1828, it was brought to Wallachia by the Russians, the seeds being lodged in the tails and manes of horses. In 1830, it appeared in Bukowina at the same time that the cholera broke out. The inhabitants have, therefore, named it the cholera-thistle. As early as 1839 it was found to be spreading in Hungary. The hogs and sheep raised in that country carried the thistle with them whilst being transported along the Danube, so that in time it appeared in Ratisbon

and neighboring places. The railroads shipped these animals to different ports and the thistle always accompanied them. No matter how tightly the hooks may cling to the fur, the seeds sooner or later fall to the ground, being brushed away by contact with some hard object or else dropped when the hair of the animal is shed.

The employment of hooks or barbs is not confined entirely to seeds. They also exist on some separable joints of small cactus, or on some slender stems of the bedstraw or tear-thumb, which therefore can secure transport through contact with wandering animals.

The seeds of some water plants are carried great distances by being embedded in the mud which adheres to the feet of large and wide-ranging birds. Some of these birds have been shot while on the wing and the seeds were found attached to the feet and feathers. A good many water-lilies provide an adhesive material for their seeds and by means of it they can cling to birds and be carried to other bodies of water. In the mistletoe, part of the flesh of the fruit possesses a very sticky bird-lime. The seed contained therein adheres to the bill of the bird, which rubs it off on the branch of a tree. In this manner

the mistletoe obtains attachment on trees, the only place where it can thrive.

Other seeds have an indigestible covering and are surrounded with a nourishing and appetizing pulp. They depend for dispersal upon animals, chiefly birds. As a rule these fruits have a bright color, which conspicuously displays their position and causes them to be readily eaten by the animals. Since the seeds are protected by a hard covering, as in berries, they pass through the alimentary canal undigested and unharmed, and are voided at a considerable distance from where they were eaten. The colored fruits are abundant on trees, shrubs, and tall-growing vines, where birds mostly frequent, as well as in low-growing herbs, where they are eaten by ground birds and other animals. It has been noticed that red is a common color and most conspicuous against the green of the foliage. Purple and blue appear in autumnal fruits which ripen when the leaves have turned yellow or red. White occurs in some berries, that grow in somewhat dark shady places near the ground. Before the fruits ripen, they are usually sour or astringent and unpalatable. Their color is then green like the foliage and the birds are not at-

tracted. Sometimes an inedible core is present in the fruits (*e. g.* apples). It is carried away, the fleshy part is eaten, whilst the core is dropped. In others (*e. g.* oranges) the slippery seeds are not swallowed at all but are scattered about, as the pulp is devoured. Nuts are carried away and buried by squirrels and blue jays. At times they remain untouched underground and begin to grow in the following spring.

The birds are the principal agents employed in this particular mode of dissemination, as can readily be seen from one or two examples. In 1770, the herb called pigeon-berry was brought from North America to the area of Bordeaux. The plant is beneficial because it gives a certain coloring to the wine. Due to the birds, this berry has spread over the entire portions of Southern France to the Pyrenean Valleys on the one side and through Switzerland to the Tyrol on the other side. There was a time, some years ago, when the famous old Colosseum of Rome had 261 species of plants, that came from different parts of the world. It is easily explained when one considers the fact, that the Romans had birds and animals of every description brought to their city for amusement. The southwest tower of the Cologne Cathedral, which had

remained incomplete since 1437, displayed 22 species of plants in 1865, that is, after some 400 years.

Finally, the noblest of all God's creatures, man, has also aided in bringing plants to new localities. He may have acted unintentionally or purposely in this regard, but the effects are readily noticed.

Near the sources of the Senegal and Gambia Rivers in Africa, at Futa-Dialon, Hecquard found a grove of orange trees. The story runs that merchantmen halted near there and were anxious to receive shelter from the natives. While waiting for a kind invitation, they ate oranges which they had brought with them from some Portuguese settlement. The seeds of the fruit were scattered round about and from one of them are said to be derived all the orange trees now growing in that vicinity. The grateful Mandingo-negroes consider the orange tree sacred and forbid their own people from partaking of its fruit, although strangers are at liberty to do so.

The primrose was brought from North America to European gardens by early French explorers. In 1614, Prosper Albinus of Padua had it planted in his garden. Now it is found in all parts of Europe. It possesses the characteristic

of unfolding its flowers at dusk and then gives a pleasant odor. This fact, together with the conspicuous yellow floral color, shows that it depends for its pollination upon the moths that fly about at night.

The weeping willow is a tree that every one has seen at some time or other. Its original home is Southern Asia. Besides undergoing the process of pollination and eventual dissemination, it can be multiplied by simply cutting off one of its twigs and placing it in the ground. The construction of the twig is such that it can absorb moisture from the soil for a considerable time. Whilst doing this, it produces rootlets which then provide the necessary nourishment. All slips of a willow tree can function in the same manner. There is a report that the English poet, Alexander Pope, was once presented with a basket of figs. The basket was said to have come from Asia Minor and consisted of the flexible branches of a willow that grows in Persia and Syria. One of the branches happened to have a green bud. So for the sake of experiment and curiosity, the poet placed it in the ground. It thrived and from it, are said to have come all the willows now found in Europe. On the island of St. Helena, Napoleon's grave was shaded by a willow tree

that caused a great controversy. It was thought to have been an indigenous willow, but Laudon, after a thorough investigation, established the fact that it came from a European tree, and was brought to the island in 1810. Laudon also states that, in 1730, a French merchant sent the first specimen from the Orient to England, where it was planted in the parks at Twickenham. From there it spread over England and on the continent. This seems plausible, since twigs from time to time may have fallen into the streams and rivers, thus making their way toward the English Channel. In time, that body of water may then have carried other twigs to the mainland, where they took root. One fact in support of such an explanation is that nearly all the willow trees of Europe at one time were of the female sex and never produced seeds. However trees of the male sex are now to be found there, so that pollination can occur.

A European plant by the name of "greater plantain" was called the "Footstep of the White Man" by the American Indians. Wherever the white man settled, this plant was sure to make its appearance. On the other hand, the century plant and the cactus were taken from our continent to Europe about 1561. These plants have

so multiplied as to be now abundant in Southern Spain, Italy, Sicily, and on the Canary Islands.

One of the best known migratory plants is the Canada fleabane, which also goes by the name of marestail or bitterweed. It was first noticed to grow abundantly near Paris, in 1655. According to a report, it was brought from our continent to Paris on a branch that acted as a basal support for a mounted bird. Now, it is mentioned in every botanical register of Central Europe. Furthermore, it has travelled eastward through Asia and perhaps it will enter North America again by way of the Pacific. It is only a weed, that is spreading far and wide, but it is beneficial to man. From it is distilled the volatile oil of fleabane, used in making "mosquito dope" and employed by people who have occasion to go where mosquitoes are troublesome. It is also used in medicine.

The ships which man builds also aid in spreading plants to foreign shores. In the middle of the 17th century, a vessel carrying a species of narcissus from Japan, was wrecked near the shores of Guernsey. The bulbs of the plant floated on the waters and were washed ashore. They soon developed in the sandy soil. Later on,

the inhabitants of the island cultivated the plant and now it forms an item of trade.

The transportation of objects may also assist in the distribution of plant-forms. In Denmark, at one time, there were found six plants that really belonged to the Italian flora. For a long time no satisfactory explanation could be given regarding their first appearance in that distant country. It was recalled that they had first appeared around the year 1840. At that time the masterpieces of Thorwaldsen were shipped from Italy to Denmark. The works of art were packed in hay and most likely, seeds of the strange plants were present and in this manner found their way into the country. Wool would form another means of distribution. Port Juvenal, near Montpellier, has been a great centre for wool and the manufacture of cloth ever since the 11th century. Close to the harbor, is a level stretch of ground, where wool coming from all parts of the world is washed and dried. Every year, strange plants make their appearance in this locality. They must have come from seeds, that were hidden in the wool and fell to the ground during the cleansing process. Thus far, 387 species of plants have been counted and of

these, 52 species come from unknown places or areas of the globe, that have not as yet been investigated by the botanist.

The above facts, excerpts from God's immense Book of Nature, portray the wonderful manner in which He manifests His power and wisdom. Marvellous, indeed, are the structures, functions, and arrangements of the various individuals of the plant-world. The most skillful human being would not be able to produce even the apparently most insignificant of them all. They seem to be rather simple and are often spoken of as if they involved no complexity. However, they are stupendous in their intricacy and vastness and make the relation of Almighty God to their origination and history as inscrutable as His relation to the construction and orbital arrangement of the stellar bodies themselves.

In conclusion there might be quoted a passage from that wonderful Hymn of Creation, concerning whose compass, truth, and grandeur, the great Humboldt expressed his astonishment: "How great are Thy works, O Lord? Thou has made All Things in Wisdom: the earth is filled with Thy riches" (Ps. ciii, 24).

CHAPTER VII

WONDERS OF INSTINCT

The activities of many individuals of the animal kingdom are a source of wonderment to every one who, upon observation, will pause for a moment's reflection. It may have been noticed what means these creatures employ to protect themselves and to evade danger; how with cunning and stealth they go in search of the necessities of life, and again in what manner they provide for themselves and their offspring. Their behavior and the fruits of their labor have attracted the attention of poet and mentor, with the result that we are asked to learn a lesson from these humble creatures. In many instances, the remarkable characteristics become manifest from the very first days of the animals' existence, and throughout their long or short span of life these traits remain essentially the same. When it is considered that these animals do not possess the sublime mental faculties of man and cannot lay claim to the training and experience accorded to him, the prob-

lem must be solved in some other manner. These phenomena are attributable to a natural impulse or propensity called instinct.

Alfred Russel Wallace, however, says: "I decline to accept the theory of instinct, where all other plausible modes of explanation have not been exhausted. If instinct means anything, it means the capacity to perform some complex act without teaching or experience." To show his position regarding the matter, he also tells us, for example: "Birds do not build their nests by instinct, but by memory. The young birds before they leave the nest, have ample time and opportunities of observing its form, its size, its proportions, the materials out of which it is constructed and the manner in which it is arranged." In accord with this line of reasoning is Charles Darwin, who remarks: "It can be clearly shown that the most wonderful instincts of the hive-bees and among ants could not possibly have been acquired by habit. A little 'dose of reasoning or judgment,' as Pierre Huber expresses it, often comes into play."

Also at the present time there are persons who claim that the remarkable characteristics of animal activity are the result of inheritance and may be improved by reflection and conscious effort.

This point of view leads to the further assertion that the activities of animals can be placed in the same category with those of man, in fact there is no essential difference in this regard between man and the animals; whatever difference does exist is only one of degree. However, in these pages examples will be furnished to show that such opinions do not agree with facts, if rightly interpreted, and that whatever the animal does, is to be ascribed to instinct alone, which, as Wallace states, is a "capacity to perform some complex act without teaching or experience." This quality is innate and comes from a Superior Intelligent Mind, which has created all things and has endowed the animal with a wonderful mode of action. Furthermore a "little dose of reasoning or judgment" on our part will lead to the understanding of St. Paul's statement that "the invisible things of Him, from the creation of the world are clearly seen, being understood by the things that are made" (Rom. i, 20).

The feathery creatures at the time of incubation will serve as the first example. The hen during the hatching season will sit on the eggs for a certain definite length of time. This may be three weeks, or even more, or less, depending on the species of fowl. But how should the hen

know that exactly three weeks, say, are required to bring about the wonderful change from an apparently structureless mass into a chick of greatest complexity? The knowledge could not have come from its mother-hen, because she also came from an egg, and therefore she had no opportunity of receiving the necessary instruction. It does not seem plausible that the embryonic chick within the egg shell employed a "little dose of reasoning or judgment" and calculated that exactly three weeks were required for its own development. Yet, somehow, this characteristic has passed on from one generation to the other, just as it is found today. A fictitious goddess could not have employed her magic wand and bestowed the power upon the species, because such goddesses have only fictitious influences. Nor could any "Force" of itself in Nature have done so, because this would only be able to act in virtue of some one or something that caused it to be active. The only way to solve the difficulty is by giving credit for this characteristic incubating quality to an Allwise Creator Who planned all these things from the very beginning. This is the only plausible explanation of the whole problem.

There is also the significant activity of nest-

building of certain animals. This work is not limited to birds. The reptiles make holes in the ground, wherein they lay their eggs, and then leave the hatching process to the heat derived from decomposing vegetable matter or from the sun. The squirrels build nests of moss, leaves and grass in the forking portions of trees, or in the hollow of a branch. Spiders, as will be seen presently, make nests of silk by simply joining together the edges of leaves with silk thread or, as in the case of the Tarantula, dig an irregular burrow which is lined with silk. However, it is among the birds that the most wonderful examples of nest-building are to be found, though Fabre claims this distinction for the spiders.

In the construction of bird-homes there is always something purposeful, even though the winged architect may not be conscious of this fact. The nest is usually built in a secure place, concealed and inaccessible to other creatures, thus giving safety to the eggs and the young birds that come forth from the shell. Since the eggs require a certain temperature to be hatched, without which development cannot take place, it is noticed that a good many birds construct the nests so that the heat of the sitting hen is retained within. When the young forms finally appear, the nest acts as

a convenient place for feeding them, and also as a comfortable abode until they can fly away. The same activities and the same form of construction are observed by each subsequent generation.

All nests are not alike, they do not show the same elaborate arrangement or complexity of structure. However, each nest is characteristic of some typical kind of bird. The terns, or sea-swallows, that gracefully sail over the surf-beaten shore and the wind rippled bays, make only slight depressions on sandy beaches. Near Woods Hole, Massachusetts, an entire island forms the nesting center for these birds. The eggs that lie in these simple nests are surprisingly similar in shape and color to the pebbles that surround them. The sea-gulls show a more elaborate arrangement in their nests. Sandy or marshy soil is chosen, but the depressions are lined with weeds, grass, and leaves. The ducks and geese employ fine soft plumage for the purpose. The same may be said of the ground-nest of the eider-duck, although here a covering of down is furnished, which can be drawn over the nursery whenever the mother bird goes off in search of food.

Other birds build mounds. In the Tropics,

some of them place heaps of decaying leaves over the eggs, a procedure similar to that employed by the reptiles. The heat produced by the decomposing matter is sufficient to hatch the eggs. The swallow chooses a place against a chimney or rafter, and its nest is made of mud and strengthened with pieces of straw. The interior furnishings consist of feathers and soft grass. The long-tailed tit-mouse builds an open-topped nest in the branches and employs a coarse material for the exterior and moss and feathers for the inside. In one of their nests 2,379 feathers have been counted. The tailor-bird sews together the edges of leaves with a thick vegetable fibre. Many other types of nests could be mentioned, but the above suffice to show that the various birds build their abodes according to some plan and that they are guided by instinct. In each case the nest is complete when the offspring creeps out of the egg-shell, and, when its own time comes, the bird is able to construct a similar abode.

However, the Darwinist will not ascribe this to instinct, and in the present case the following would most likely be the "possible mode of explanation." The young birds, upon coming out of the shell, look around and see what sort of a place they are in. They notice that they are up

in a tree and in something growing on trees. This is noted down, since memory will help them when their time comes. But after a while, when they examine the situation more closely, and a "little dose of reason or judgment" is employed, they realize their mistake. The nest was *built* there, and since they too at some future day will be obliged to build a nest, they "observe its form, its size and the materials out of which it is constructed." These facts are impressed on their memories. This is indeed an interesting explanation. But no facts have been furnished to show that such is really the case. Until a better explanation is forthcoming, the theory of instinct is quite satisfactory, as instinct means the God-given "capacity to perform some complex act without teaching or experience."

The flying habit of the birds is also remarkable. Five young swallows were once placed in a small box and the front portion screened off with wire. This box was placed near their own nest. Each day the parents were wont to feed the young through the openings, and all but one survived the test. One day the screen was removed, whereupon the fledglings, unsteady for the moment, soon took to the wing. In their first attempt they flew about ninety yards. After

having been kept in the cage again for a few days, they were once more set free. This time, they were stronger and one of them immediately took to flight and soared over the beech trees. The box had been of such small dimensions that the birds could not even stretch their wings, much less receive any training while imprisoned, yet they knew how to fly the very first time they were placed in the open. Could a "dose of reason or judgment" have given them this facility?

In the insect world there are also many wonderful evidences of instinct. One creature, the caterpillar eater, or ichneumon fly, places its eggs on the caterpillar and calculates, from the size of the individual, just how many eggs are to be deposited. When the maggots appear, they devour only certain definite portions of the caterpillar, so that this animal can still continue to live. If the more vital portions were removed in the early stage, both the caterpillar and the grub would die. Later on, however, the immature flies devour the other portions and in time construct small cocoons alongside their victim. These maggots are then further protected by a silk covering, which the dying caterpillar weaves for them. A "possible explanation" of this phenomenon, according to Darwinists, would be that the maggots had taken

up a course in anatomy, since they know just what parts of the caterpillar are to be eaten first. The final act of "Brotherly love" apparently remains unexplained, unless perhaps the "theory of instinct" is accepted.

There are two species of beetles, which in their mature state, are usually found in the nests of small ants, called Myrmica. They live in these nests from September till the following May, and from October to March they are found in a deep sleep. However, the larval beetles appearing in the early summer, do not live with these ants, but in the community of another species called the Formica. A migration from one camp to the other takes place each year and it is twofold. In May the female beetles leave the Myrmica and lay their eggs in the nests of the Formica. In September the developed beetles leave the latter and go to the Myrmica. The change of abode is for the purpose of protecting the Myrmica species. If the beetle-eggs were to be laid in the Myrmica nests, the larval beetles would devour with avidity the young unprotected ants. Thus, instinct impels the female beetle to go to another community where the young offspring can do no harm. When the mature beetles come back to the Myrmica, they are accorded every considera-

tion by their hosts. The ants feed them and in return they give nourishment to the ants. Apparently the very existence of the beetles depends on the feeding methods of the ants. If this did not occur, the beetles would die of starvation. In return they furnish the ants with some highly appetizing juices, which they secrete, and thus a sort of "mutual friendship" exists. It has never been noticed that the ants harm the guests in any way. But it has been observed, that a beetle evidently outside of the colony was dragged to the interior by the ants. However, the fact that the migration takes place with regularity can only be explained as an arrangement of Divine Providence.

It has been mentioned above that the ichneumon fly provides caterpillars for its young and treats the prey so as to be inert but not lifeless. The solitary digger-wasp shows similar traits. The female of each species of this wasp digs its own peculiar burrows in the earth with its strong jaws and first pair of legs. In the interior it hollows out a storage chamber and then goes in search of food. Its own food consists of ripe fruit and nectar, but that of the young is entirely different. This depends on the species of the digging-wasp. Some require flies, others beetles,

grasshoppers, spiders, caterpillars or bugs. In the case of the caterpillar variety, the female wasp, when it has found the prey, swoops down upon it and endeavors to bite and sting the victim. A short struggle ensues, but eventually the wasp grips the prey and stings it in definite nerve-centers, so that the caterpillar is paralyzed. By means of its teeth and forelegs the wasp then drags it to the burrow. In its backward locomotion the wasp at times travels over sixty feet over all kinds of obstacles. Upon arriving at the burrow, the wasp seizes the caterpillar with its mandibles and backs in. The victim is made fast in the storage chamber and a single egg is attached to its skin. The wasp then goes in search of another caterpillar and the same process is repeated. Usually two caterpillars are found in a storage chamber. The burrow is then filled in lightly by the female wasp and a similar one is made elsewhere.

It is to be remembered that the offspring, in this case, never sees the activities of the parent form. But it can do the same when its own time arrives. The storage room is constructed and the caterpillar is stung in three nerve centers in the front part of the body as well as in the hind portion. Here again, if the idea of instinct be

rejected, a "little dose of reason or judgment" must have been employed. As an example of the latter view, the remarks of Eimer may be quoted. This eminent scientist says: "What a wonderful contrivance! What calculation on the part of the animal must have been necessary to discover it! The larvae of the wasp require animal food. Dead food enclosed in the cell would soon putrify, living active animals would disturb the egg, and accordingly the wasp paralyzes grubs and packs them like sacks of meal one after another in the cell. How did she arrive at this habit? At the beginning she probably killed larvae by stinging them anywhere and then placed them in the cell. The bad results of this showed themselves; they putrified before they could serve as food for the larval wasps. In the meantime, the mother wasp discovered that those larvae which she had stung in particular parts of the body, were motionless, but still alive, and then she concluded that larvae stung in this particular way could be kept for a long time unchanged, as living motionless food. It may be suggested that the wasp only paralyzed the larvae in order to carry them more easily; but even if this were the case, she must, since she now invariably acts in this way, have drawn a conclusion by deductive reasoning. . . . In this

case it is absolutely impossible that the animal has arrived at its habit otherwise than by reflection upon the facts of experience." ("Organic Evolution.")

These are the words of a professor of Zoology and Comparative Anatomy at the University of Tübingen. According to him the wasp has acquired a habit by "reflection upon the facts of experience." If the insect were as old as some of the Redwood Trees of California, it surely would have had experiences. But the wasp does not live that long and, furthermore, it has no opportunity of relating its experiences to the offspring buried beneath the soil, which it never sees. Perhaps some astral body, evolved according to du Prel's idea, comes back when the young wasp appears above the surface of the ground and imparts the necessary information from the "facts of experience." But why enhance Eimer's theory? Such an assertion can only be made by one disregarding or denying the work of the Creator, Who foresaw and arranged all things. The power is inborn and experience has nothing to do with it. Each wasp digs a burrow just like its parent before it, and each wasp knows just where to sting the prey for storing purposes. There is not the same anatomical arrangement in the dif-

ferent creatures used as food: beetles, grasshoppers, spiders, and bugs. Yet each species of wasp stings definite nerve centres and causes paralysis. No one has ever observed that experiments are first made, but the very first attempts bring the desired results. A wasp's life is too short for experimental stages.

Another solitary wasp shows an even more remarkable instinctive quality. It constructs a vase-like nest of clay and stones. The cementing fluid is furnished by a secretion coming from the mouth. When all is in readiness, the eggs are deposited within, and five small caterpillars are procured as food. In this case, the prey does not seem to be completely paralyzed by the wasp and if simply laid in the nest, these caterpillars by their movements would perhaps crush the tender eggs. To obviate the difficulty, the wasp suspends the caterpillars from the top of the nest by means of a thread. Thus, the bending and tossing will not harm the eggs. The young wasp, emerging from the egg, climbs along the sides of the nest and feeds on the caterpillar provided by the parent form. When all the arrangements are complete, the opening of the nest is closed by a cover made by the female wasp. Having completed its task, it departs and

never visits the nest again. No doubt, according to Eimer, or Darwin, the young wasps in the nest, study closely the elaborate arrangements made in their behalf by the parent wasp and impress these facts upon their memory.

There are certain beetles which possess the peculiar trait of burying decaying animals, whose obnoxious odors would otherwise contaminate the air. They are concerned with small animal forms like snakes or moles, just as the vultures prey on the larger decaying carcasses. By digging away the soil underneath the dead bodies and by pushing and adjusting, the beetles are able to bring about the burial. A great amount of exertion is required, but they are equal to the task. The carcass is used as food for the young beetles that come forth from the eggs laid upon it. Never are there more than five maggots found on one of the buried animals. If there were more, the food material would not be sufficient for all.

The skill of the garden-spider in constructing its web is also noteworthy. Even the preparatory stages point to something purposeful. The place for the web must be carefully selected. There is the direction of the wind to be considered, the amount of sunlight, and the abundance of insects

in the neighborhood, and furthermore, the web must remain unmolested. When the proper site is found, there is need of attaching the frame of the net to suitable supports. The work of spinning the web then begins.

The threads of silk, of which the net is made, consist of the finest and strongest of natural products. These threads come from a gummy fluid that the spider produces in spinning tubes near the end of the body. All the silk threads of a web are not alike. One kind is used for the outer framework and radial lines, a second variety is found in the circular lines, a third quality is employed to entangle any insect that happens to alight upon the web, and a fourth is used by the spider when it forms the cocoon.

In building the web, the spider first makes the outline. A long thread is produced, and this is fastened to some object through the action of the wind. Then the creature proceeds to some leaf or twig, attaches the thread, and stretches it tightly with its claws. By means of another thread, which it produces, the spider falls straight downward and so produces one of the vertical lines. The other sides of the outline are made in a similar manner. The lines corresponding to the spokes of a wheel are then produced. When the

skeletal portion is complete, the spider returns to the center and travels in ever larger circles, producing thread as it does so, and forms a temporary spiral. The other spiral lines are made of more sticky threads, by means of which the insects are entrapped.

The pattern of the spider's web always remains the same. Professor Thomson remarks: "As the garden spider grows older, the thread becomes thicker and the web larger; there are a few more radial rays and a few more loops in the spiral, but these differences are connected with the increased weight of the spider and the increased size of the spinning organs. There is more material to work with and the web is more substantial, but there is no real change or need of any." Usually the spider completes its net in about half an hour. Then it awaits the arrival of some victim. Should a fly have the misfortue of alighting upon the web, the spider immediately sets to work, weaving her most sticky threads around the insect and fastening it securely. Then it thrusts its poisonous organ into the fly and kills it. After the spider has sucked the juice of the fly, it casts off the victim's skin. A similar fate awaits any butterfly that may be entangled. Even if an impetuous and dangerous wasp drops

on the net, the spider will soon employ her meshes to make it powerless and then devour the prey.

The honey-bee furnishes another wonderful example. It constructs cells in its honey comb, that baffle even the most expert architects and builders. "Each cell is a hexagonal tube, and it has been shown that, by adopting this form for themselves, the bees have solved with mathematical nicety the problem of how most closely and strongly to fit the cells together. But not only have the bees combined these advantages with the greatest thrift in material, they have also bound the cells together in a comb, and attached it to the hive-walls in a way that combines symmetry and strength, whilst yet permitting of traffic,—incomings and outcomings—and ventilation without mutual interference. The diverse kinds of cells are evolved from one another so as to exclude waste of room." (Gamble.) The ability to produce such an elaborate arrangement could only have come from Almighty God. In each creature there is a certain directive power, which becomes manifest each time the bees construct their hive. The work is not done at random, but in virtue of an instinct. The bees simply work according to the plans of their Creator.

One case might be mentioned in which, alas!

there was no sign of a "little dose of reason or judgment." It is taken from the writings of the entomologist, Fabre, whom Darwin has called the "inimitable observer." On one occasion he lined a number of caterpillars on the rim of a palm-vase in his garden. This rim was covered with silk. A closed circuit was formed and it was a game of "following the leader." These caterpillars travelled around the improvised track "for seven times twenty four hours" and covered 335 laps or somewhat over a quarter of a mile. Yet not one of them deviated in the test of endurance, nor profited by "reflection upon the facts of experience." Instead, "the caterpillars in distress, starved, shelterless, chilled with cold at night, cling obstinately to the silk ribbon covered hundreds of times, because they lack the rudimentary glimmer of reason which would advise them to abandon it."

Another instance of "unfathomable stupidity" is recorded by Fabre in connection with a spider, the "Narbonne Lycosa." The female, after having rolled up the eggs in a silk mat prepared by her, keeps the egg-case attached to her spinnerets until hatching time. She drags it around at all times and defends it with great courage. Fabre took the case from one of them by means

of forceps and substituted a cork ball, which he had polished with a file and cut to the same size as the egg-bag. If her spider brain had contained the least gleam of sense, she could have detected the ruse. But "the silly creature pays no attention. Lovingly she embraces the cork ball, fondles it with her palpi, fastens it to her spinnerets and thenceforth drags it after her as though she were dragging her own bag." He then placed the detached egg-bag among four or five cork balls to see what would occur. The animal rarely recovers the bag and then it seems only because it is the nearest. "Attempts at inquiry, attempts at selection there are none. Whatever she snaps up at random, she sticks to, be it good or bad. As there are more of the sham pills of cork, these are most often seized by the spider." How easily the spider could have employed a "little dose of reasoning," especially since she made the egg-bag and had "ample time and opportunities of observing its form, its size, its proportions, the materials out of which it is constructed and the manner in which it is arranged."

Newly hatched chicks have also been observed. The wonderful transformation from egg to chick may now-a-days be brought about without the

aid of the incubating hen. Mechanical contrivances—incubators—can give the same results. In this case, the chicks never see the mother hen and they are never "taught" to seek food. The observations of Eimer himself will prove of interest. He placed some seed in front of newly hatched chicks and they took no notice of it. Then he took some of the seed in his hand and let it fall on the floor. The chicks immediately pecked at it and swallowed it. At another time a fly happened to dart past the eyes of a chick that had come out of the shell only one half hour before. The chick pecked at the fly as if it had always been accustomed to catching flies. All the movements were accurate and suited to the purpose. Had the fly been caught, the chick no doubt would have enjoyed it as much as a mature fowl.

Eimer claims that the chick brought into the world with it an "inherited mental image of the flight of a fly!" He also remarks that the behavior of the creature towards the fly was a consequence of innate instinct like that of itself and its brethren toward the seed. The inherited mental picture does not sound scientific, but the innate instinct will be accepted, and this latter has

come not by way of experience but from an all-wise Creator.

Chicks that had been hatched by a hen were also observed by Eimer. As he himself assures us, they were taken from the nest and knew nothing of the world, nor did they have any experience whatsoever. Yet when food was placed in front of them, they pecked at it, and one of them in the first attempt touched the food with as much accuracy as if it had done so for ever so long. On the fourth day they were placed outdoors in the gravel in the garden. For the moment everything seemed strange to them. Food was given to them on a wooden tray, just as happened in the indoor experiments, but they disregarded it and soon began to peck at the gravel for the purpose of obtaining food. They also snapped at the most varied objects such as bits of wood, etc., and threw away what was useless. After a little while they acted as naturally as if they had always been familiar with their surroundings.

On another occasion, while indoors, he happened to make a noise that frightened the chicks. But when he imitated the voice of the mother hen, they ran toward him "as if old memories

were awakened in them" and sought protection. As a result of these observations, Eimer thinks that it is reasonable to ask whether the sitting hen may not chatter sometimes on her nest and whether the chicks may not thus, even in the egg, hear something of the fowl's language!

Mr. Douglas Spalding also recorded some observations with regard to young chicks. He writes: "When one of my pupils was twelve days old, while it was running about near me, it uttered the peculiar cry with which fowls denote the approach of danger. I looked up and saw a hawk which was circling at a great height above us. Equally striking was the effect of the voice of the hawk for the first time. A young turkey which I took possession of, when he began to chirp in the still unbroken egg-shell was, on the morning of the tenth day of his life, just engaged in taking his breakfast out of my hand, when a young hawk in his box close by, uttered a clear 'cheap, cheap'; the poor turkey shot like an arrow to the other side of the room and stood there motionless and paralyzed with terror, till the hawk gave a second cry, when he ran out of the open door to the farthest end of the lane, and there remained for ten minutes, crouched in a corner. Several times more in the course of the day he heard that dis-

torting sound and each time with the same symptoms of fear." It would be difficult to explain this fear of the hawk on the part of the chick and turkey unless the "theory of instinct" were accepted.

To enumerate all the instances of purposeful activity as found in the animal kingdom would fill volumes. In each case, however, they are to be ascribed to an Allwise Designer, Who arranged the internal structure of every animal and had the external world brought into harmony with it. For example, it is seen how each animal is able to find and choose its own particular kind of food. It is able to discern the beneficial from the poisonous herbs and berries. This is owing to the sense of smell that the Almighty has given. As places of habitation, the beaver, the fox, etc., build their lairs, the various kinds of bees, ants, and birds, their peculiar nests. The deer in time of danger employs his antlers for the purpose of defence. Thus any number of examples could be described.

But it is claimed, according to another group of men, that all these phenomena are the result of intelligence in the animals. All living creatures, we are told, possess a "psyche" which is provided with faculties of recognition, conscious

effort, and decision. The faculties are not of the same perfection in man, animals and plants, but essentially the faculties are not different one from the other. There is only a difference of degree of perfection. Such statements appear in books on animal psychology written in popular style for the unwary and gullible. In these books the human spirit and the soul of the animal are placed in the same category.

This neo-Lamarckian view mistakes sensation for spiritual life and instinct for intelligence. The statement that the animal possesses reason and consciousness of duty and effort as well as man, is false. The soul of man and the souls of the animals are substantial components of the organisms. There is an essential difference between a "psyche" that thinks and shows a free self-determination as manifested by man and a "psyche" whose faculties do not extend beyond the provision of sensitive recognition and sensitive endeavor, as found in animals.

The many interesting and momentarily mystifying phenomena of instinct cannot break down the barriers existing between man and the animals. Hence, the endeavors of certain writers "to follow up analysis with synthesis and generalize the origin of instinct in an all-embracing

view" do not meet with our approval. The entomologist Fabre remarks: "Because I have stirred a few grains of sand on the shore, am I in a position to know the depths of the ocean? . . . Life has unfathomable secrets. Human knowledge will be erased from the archives of the world before we possess the last word that the gnat has to say to us." Regarding those who seek to have their generalizations accepted everywhere, he writes: "Success is for loud talkers; the self-convinced dogmatists. Everything is admitted on condition that it be noisily proclaimed. Let us throw off this sham and recognize that, in reality, we know nothing about anything, if things were probed to the bottom. Scientifically, Nature is a riddle without a definite solution to satisfy man's curiosity. Hypothesis follows hypothesis; the theoretic rubbish accumulates; and truth ever evades us." (From M. Maeterlinck's "The Insect's Homer.")

In denying the essential difference between the psychic faculties of man and the animal, the above school of thought not only raises the brute to the level of man, but also degrades man to the level of the brute. The interpretation of animal activities according to human standards has for its aim the overthrow of a sublime moral

code established for man by reason and divine law. Should such views ever be accepted by mankind in years to come, the rank and file of humanity would resemble a herd of unreasonable animals, whose "spiritual life" would consist in the unbridled gratification of the meanest impulses. But it is to be hoped that man, made to the image and likeness of God and endowed with the noblest of faculties, may see the insidiousness of this argument and counteract most strongly its venomous influence on human thought.

CHAPTER VIII

ANIMAL CAMOUFLAGE

DURING the last great war, the various nations in the strife employed many devices, with which they endeavored to outwit the opposing forces. The forms of artifice and color-schemes were such as to perplex at times the keenest observers. On the field of battle the soldier was clad in khaki to resemble the field-grass and the soil; others wore their gray or blue in order to become indistinguishable against the horizon. The various types of vehicles were provided with a grayish or brownish hue, or were so "spattered" with different colors as to be confusing. Again, improvised thickets and forests were arranged, behind or under which the troops could march with greater security, or else lie in ambush. Upon the waters the vessels showed similar contrivances. The colorations made the ships indiscernible at relatively short distances and very often the direction of their course remained a matter of conjecture, for some time at least. Some of them

had their armament concealed behind sheets of canvass and they were so cleverly disguised as to appear like innocent-looking sailing vessels. Every means was used either to allure or to evade the enemy. Although this was a prominent feature during the late encounter, phases of it were known to past generations. In the writings of the ancients there is mention of the Trojan Horse, and Shakespeare in his "Macbeth" describes how Malcolm commanded his soldiers each to hew down a bough and carry it in front of him. The effect of this was to give the advancing army the appearance of a moving forest. At the sight of this singular spectacle, a sentinel hastened to Macbeth and reported breathlessly:—

> "As I did stand upon the hill,
> I looked toward Birnam, and anon, methought
> The wood began to move."

However, such deceptive methods are not characteristic of man only. As Dr. Dendy of England states: "The practice of bluffing is by no means an exclusively human institution." It is in the animal world that many remarkable instances of deception and imitative resemblance are in evidence. There they are used for the purpose of escaping from some enemy or of

approaching some prey more easily. Defenceless animals simulate the color, form, attitude, and even movements of other animals that are naturally protected by certain characteristics. In many cases they may resemble some inanimate object. Non-poisonous snakes have the appearance of poisonous forms; beetles may be colored like dangerous hornets; butterflies escape capture because of coloration and traits possessed by others which find protection either in offensive odors or bad flavors. Individuals like the caterpillars may have the color of green or dried leaves. Other insects may resemble a piece of wood, a twig, or the color of the sand. This imitative resemblance of one animal to another or to some inanimate form is commonly known by the term *mimicry*. Some writers make a distinction and call the general imitation a protective resemblance, whereas mimicry in the strict sense is employed to denote the imitation of other animals. For the present purpose the various facts will be considered under the following subdivisions:

Protective features;
Aggressive features;
Alluring features;

Warning features;
True mimicry.

Protective Features

The eggs of many animals especially of insects and birds show a peculiar coloration and become indistinguishable from their natural surroundings. A large green grasshopper lays its eggs in the earth. These are brown exactly like the soil in which they are deposited. The eggs of some insects have a gray-brown or a whitish color, and resemble the bark of the trees on which they are laid. The eggs of the Alpine ptarmigan are ochre-yellow with brown or reddish-brown dots like the color of its nest built of the dry parts of plants. The eggs of the sea-gull are yellow-brown and gray and resemble the sand in which they are deposited. A person may often tread on them before becoming aware of their presence.

Many animals living either in the ocean or in fresh water are discerned with difficulty in the water because they are quite colorless or possess only a slight bluish or greenish tinge. They are usually known as the "Glass animals" or "Crystal animals." In some fresh water lakes there

is a small aquatic flea which moves along in jerky fashion and keeps all its claws extended in order to seize its prey. This creature is almost crystal clear and if some water containing this variety were taken in a glass, no signs of life would be noticed. But if the water be strained through a fine cloth, a small mass of gelatine-like substance remains on the sieve, thereby showing that they are present.

The same conditions prevail in the ocean waters. Among the familiar forms might be mentioned jelly-fishes and worms. Their inconspicuousness serves as a means of protection because they are not seen by their pursuers. However, the protection is not absolute. For there exist many predaceous animals in these waters, which do not wait until they see the prey. They swim about, constantly opening and shutting their mouths as they go and in this manner procure the invisible forms as food. Their transparency protects them against the attacks of some animals but never against all.

The fishes are generally dark colored above and of light color below. To a sea-gull flying about, their color causes them to harmonize with the dark water. Yet another fish looking at them from below or from the side, would be less likely

to detect them, than if they had the same general dark coloration. The blue-fish, as an example, possesses brilliant white sides and lower body portions, whilst its back is a dark steel-blue.

In the Sargassum Sea, there are found two species of small fish which are colored like the sea-weed in which they have their habitat. The sea-horse, exhibited at times in aquaria, is a small fish so fashioned as to resemble the seaweed. A form related to it exists in the waters of Australia. Both live amongst sea-weed, to which they attach themselves by means of their tails. The Australian variety has its body covered with outgrowths of the skin, which float out in the water similar to the leaf-like expansions of sea-weed.

The common British spider-crab protects itself by breaking off bits of sea-weed and attaching them to the long hairs of its body. This is a clever disguise for the animal, which is slow and sluggish in habits and forms an easy prey to fishes. The stomach of a thornback ray was once found entirely filled with them. In Puget Sound a crab appears so exactly like the pebbles of the bottom along the shore, that it is not recognized until in motion.

Snakes living on the ground have a dull color, either gray-brown or dull black, causing them to

resemble the shadows that may prevail at the bases of the grass-stalks. One group existing in the Eastern part of the United States displays a bright green color. For the greater part of the time it lives in the branches of shrubs and its coloration makes it inconspicuous against the background.

Rabbits, wild sheep, deer and antelope have dull colors and readily harmonize with their surroundings. The gazelle varies from white on the great plains to a dark gray on the lava fields of volcanic districts. The zebra is known for its peculiar stripes and seems to be protected by this color scheme. Its habitat is in Africa. Mr. R. Crawshay remarks:—"They remain out in the sun on the plains all day long, not retiring into covert at all. They are then an intolerable nuisance to any one in pursuit of other game; indeed this may be said of them at all times. If they once notice you, they draw in and mob you in their curiosity—only, however when one takes no interest in them—for when they fancy they are the object of the intruder's attention, no animals are more watchful or cunning in safe-guarding themselves. If only their curiosity were manifested in silence, it would not so much matter, but it vents itself in snorts and thundering

stampedes, which puts every beast within earshot on the *qui vive.*" Theodore Roosevelt remarks that, at a little distance away, the stripes of the zebra become indistinct and it then appears a uniform gray.

Birds usually have a color which blends very well with their surroundings. Some, like the gulls and the terns, are steel gray or are bluish above and white beneath, so that they harmonize with the sea when viewed from above and with the sky when noticed from below. The sparrows, ordinarily found in grasses and bushes, may be speckled-brown or grayish-brown. Tropical birds, like the parrot, have a bright green color. In Jamaica, there is a small green colored bird, which is wont to remain motionless in the foliage, when any one is near it. Some people have not been able to discern it, even though they were only six feet away.

Some birds and mammals, among them the ptarmigan, Arctic fox, varying hare, and weasel, show a change of color from summer to winter. In the summer time they are grayish or brownish, similar to the leaves and rocks among which they live; in spring and autumn, when shedding their feathers or hair, they are spotted gray and white or brown and white to harmonize with the regions

where patches of snow may be found, whilst in winter they are white in color, thus resembling the snow.

A remarkable fact is the readiness with which some animals can change their color to agree with their environment. The chameleon, frogs, and certain fishes are familiar examples. A shrimp-like animal called Hippolyte is described by Gamble as follows: "The wakeful hours of Hippolyte are hours of expansion. The red and yellow pigments flow out in myriads of stars or pigment-cells: and according to the nature of the background, so is the mixture of pigments compounded to form a close reproduction both of its color and its pattern: brown on brown weed, green on Ulva or sea-grass, red on red Algae, speckled on the filmy ones. A sweep of the shrimp net, detaches a battalion of these sleepy prawns, and if we turn the motley into a dish and give a choice of sea weed, each variety after its kind will select the one with which it agrees in color, and vanish. At night, Hippolyte, of whatever color, changes to a transparent azure blue: its stolidity gives place to a nervous restlessness; at the least tremor, it leaps violently and often swims actively from one food-plant to another. This blue fit lasts till day-break and is then suc-

ceeded by the prawn's diurnal tint. Thus the color of the animal may express a nervous rhythm."

In the locust group, there are certain insects whose hind wings are of a brilliant red or yellow color. The front wings, which cover the hinder ones when the animal is at rest, as well as the remainder of the body, are colored to harmonize with the environment. Those living in the red-shale regions of New Jersey are reddish brown, while others of the same species found near the shore have a light gray color and bear a resemblance to the prevailing sands.

Other insects appear exactly like sticks both in form and color. One of them is even known by the name "Walking Stick." In Nicaragua there is a species of walking stick which shows peculiar outgrowths on its body and legs and resembles the moss on which it lives.

Another form of protection is seen in the caterpillars of the geometric moths. In color, shape, and attitude these animals resemble small twigs in a remarkable manner. When at rest they stiffen themselves up and stand out from a branch at the exact angle of a twig. The same is true of the caterpillar of the brimstone moth. It attaches its head to a branch by means of a

silken thread and can remain motionless for a long time. Very many of these caterpillars are rarely seen because of their perfect resemblance to the twigs of plants on which they feed. Other caterpillars imitate the ragged edges of the leaves of their food plants in both color and shape.

Protective resemblances are also noticed among the leaf-insects. In Ceylon a member of the locust group has a bright green color. Its wings are shaped and veined like leaves and the body and legs possess leaf-like outgrowths. The butterfly, Kalima, of India also shows resemblance to a leaf. This becomes manifest, when the insect is at rest and has its wings folded together above the body, so that the under-surface is exposed. It then appears like a dried leaf and displays imitation of a stalk, midrib and the color pattern of the leaf.

AGGRESSIVE FEATURES

Animals protected by peculiar color schemes and resemblances are very often benefited by these features when in pursuit of their prey. Birds, lizards, frogs, spiders, and pebble crabs escape detection by the foe on account of their colorations. On the other hand, they are able

to remain unobserved by the unwary insects which serve them as food. The field sparrow mentioned above has a color that harmonizes with its surroundings and can evade the hawk. Yet this coloration is also of advantage, since the sparrow can approach its insect-prey more easily.

In some cases, though, the color seems to be for aggressive purposes. In the far North most of the animals are pure white, or, approximately so, at least during the long winter. The Polar bear remains white as snow throughout the entire year. However, the Arctic fox and the great snowy owl display seasonal changes of color. The animals of the desert are colored a sandy yellow, a clayey yellow, or even have a mingling of them all. The lion is tawny and he can steal along unobserved as he crouches close to the ground towards his prey. The tiger, the ruler of the jungle, possesses the dark stripes, which resemble the vertical shadows of the reeds among which it lies in wait for the antelopes as they come to the waterside for drink. Another example of aggressive coloration is seen in the leopard and the jaguar, both tree climbers. These have peculiar blotches on their skins which resemble splashes of sunshine that come through the foliage

or they are like the confused shadows among the trees.

ALLURING FEATURES

In a work entitled "A Naturalist's Wanderings in the Eastern Archipelago" by Forbes, a remarkable instance of allurement is mentioned. In Java there exists a spider which simulates the voidings of birds and lizards upon which butterflies usually alight. The material is chalklike in color, streaked here and there with black, and surrounded by a thin border of the dried-up or more fluid portions. The spider imitating it has a peculiarly shaped body and is of a whitish color. The underside of its body is generally exposed and is pure chalk white. The lower parts of its first and second pairs of legs as well as a spot on the head and on the abdomen are jet black.

This species does not weave a web of the ordinary kind but it arranges an irregularly shaped film of the finest texture on the surface of some prominent dark leaf. The film is drawn out toward the sloping margin of the leaf into a narrow streak with only a slightly thickened

termination. The creature rests on its back on this irregular patch and holds itself in position by means of several strong spines, found on its anterior legs, which it puts under the film. The other legs are then crossed over its body. "Thus resting with its white abdomen and black legs as the central and dark portions of the excreta, surrounded by its thin web-film representing the marginal watery portion become dry, even to some of it trickling off and arrested in a thickened extremity, such as an evaporated drop would leave, it waits in confidence for its prey—a living bait so artfully contrived as to deceive a pair of human eyes even intently examining it."

The Mantid or "Praying Insect" shows peculiar characteristics. The ancient Greeks considered it a sort of prophet; the Mohammedans say that it prays constantly with its face turned toward Mecca; the Europeans know it as the preacher, saint, mendicant, soothsayer, etc. In reality, this creature is not a saint, but the tiger of the insect world. Crickets of all kinds, butterflies, bees and large flies form its food. The South American type even attacks small frogs, lizards, and birds. As Fabre writes, if the Mantis only had sufficient strength, "its bloodthirsty appetite and its horrible perfection of

concealment would make it the terror of the country side. The Prego-Dieu would become a Satanic Vampire." Its body as a whole has a perfectly peaceful aspect, but its forelimbs are murderous. This graceful body may have the appearance of either a leaf or a flower depending on the species, and it easily attracts flower-feeding insects. Some have the fore part of the body so modified as to represent blossoms, and the deception is enhanced by a gentle swaying kept up by the insect in imitation of the effect of a lightly blowing breeze. The forelimbs are provided with a double row of steely spines, in what would correspond to the thighs. They are really like saws with two parallel edges separated by a groove, in which the foreleg lies when folded. The foreleg is also like a saw, but the teeth are smaller. It terminates in a strong hook, the point of which is as sharp as the finest needle. With these weapons it seizes and kills its prey. When the victim is within reach, the forelimbs are shot out, the talons strike the prey, which is then dragged backwards between the two saw-blades of the thighs. "The vise closes with a movement like that of the forearm upon the upper arm and all is over; crickets, grasshoppers and even more powerful insects once seized in this trap

with its four rows of teeth, are irreparably lost. Their frantic struggles will never release the hold of this terrible engine of destruction." But even on other occasions these Mantids are quite pugnacious as they fence with their limbs, "like hussars with sabres," the larger frequently devouring the smaller and the females the males. The Chinese keep them in bamboo cages and match them like other people would bull-dogs or fighting roosters.

In Algiers is found a lizard having bright red folds of skin at the corners of its mouth. In color and form, it has the appearance of blossoms of desert plants. These features enable it to ensnare the insects that go in search of nectar and pollen.

Another form of allurement is that manifested by the angling fish. It is a large, flat, soft fish, about three feet in length, and almost half as broad as it is long. A soft stumpy tail stretches out behind and by means of a kind of wrist-joint at the fins, it can creep along noiselessly. Ordinarily it lies hidden in the sea-weed or sand. The mouth gapes wide open and the pointed teeth are bent backward to allow its prey to enter. Around the head and body, the skin is fringed giving the appearance of sea-weed. It has

several spines on the head and back, but the foremost is tapering and long, similar to a fishing rod, with a lappet at the end like a bait. When the shallow water ripples over the head, the lappet sways to and fro and the unwary fish come up to nibble at it. The angling fish then gradually lowers the rod, while the nibblers follow, until opening its wide gape, it gulps them down. At times the victims are as large as the angling fish itself. It then lies passive with its swollen stomach, until the food is digested. One of these fish was once found with seventy herrings in its stomach.

WARNING FEATURES

Animals at times are dangerous or disagreeable to their pursuers, because they possess some means of defence or have an unpleasant odor or taste. Bees, wasps, hornets or yellow-jackets are provided with their characteristic sting. In order that they be recognized by birds, lizards, frogs or mammals, they display prominent bands of yellow or white colors or even metallic lustre as seen in the blue wasps. These colorations also afford a means of protection, because if any predaceous animal had once endeavored to seize them, it felt

the effects of the sting and would not pursue them in the future. Experiments have proven this. The peculiar color patterns therefore act as a warning. Besides, were they not conspicuous, other animals would mistake them for edible forms, and even though not devoured, they would be grasped and injured and finally rejected.

As a rule, bugs are disagreeable in taste and odor. Not only do they advertise themselves by their colorations, but in many instances they possess a bodily construction that is easily recognized by predaceous forms. Similarly a great many beetles prove unpalatable on account of their hard shells, whilst some of them have a disagreeable flavor. These also possess peculiar markings and protective signs. The Colorado beetle has conspicuous stripes running down its back, and even in the larval stage it is bright colored and noticeably spotted. Birds, lizards, frogs, and toads easily recognize them and do not seize such varieties.

Doubtless there are numerous insects which are protected in this manner, and a great many are still to be recognized and described by the naturalist. A. R. Wallace mentions three families of butterflies found in three great tropical regions: South America, Southern Asia, and

Africa. Their wings are large, but they fly slowly. "They are always very abundant and they all have conspicuous colors or markings, so distinct from those of other families, that in conjunction with their peculiar outline and mode of flight, they can be easily recognized at a glance. Other distinctive features are that their colors are always nearly the same on the under surface of their wings as on the upper; they never try to conceal themselves but rest on the upper surfaces of leaves or flowers; and, lastly, they all have juices which exhale a powerful scent, so that when one kills them by pinching the body, the liquid that exudes, stains the finger yellow and leaves an odor, that can only be removed by repeated washings." To insect-eating birds or lizards this odor must be quite offensive as they have not been noticed to go in pursuit of such butterflies. Furthermore, Wallace remarks that their wings were not found strewn in the paths of the forests where numerous wings of edible forms had been left behind by insect-eating animals.

Lizards, in general, have a color that makes them more or less inconspicuous for the purpose of protection and aggression. Yet in Mexico and Arizona there is found a species, called the

Gila monster, said to be the only known poisonous lizard. It differs from the ordinary forms in displaying a conspicuous mingling of colors, namely, tints of blackish-brown, yellow and orange.

Amongst the mammals warning features are not much in evidence. However, the skunk deserves mention. It is amply protected by the secretion of a liquid of a very offensive odor, which it can eject at will. To some extent, therefore, it can protect itself from aggression and makes known its presence by its large bushy tail and its conspicuous black and white color. Being a nocturnal burrowing individual, it may also be benefited by these colors when in search of prey by moonlight. The black portions of the skin would resemble shadows and the white markings, blotches of light. A form allied to the skunk has been characterized as a "savage and diabolical-looking weasel." It is the Grison, also known as the "Huron." Its color is grayish-yellow above and blackish beneath. "It almost rivals the skunk in the power of the odor which it can emit when enraged. A trapped specimen was placed in a cage 50 yards or so from the house, and even at this distance it was disagreeably easy to tell when any one visited the

animal—at least when the wind set in the right direction" (Proc. Zool. Soc., 1894).

TRUE MIMICRY

Many animals advertise a characteristic which they do not really possess. Such creatures are innocuous and inoffensive, not being protected by any stings, disagreeable exhalations or flavors. Although palatable and readily eaten by the foe, they escape destruction by resembling other forms that are avoided. According to Wallace, this is true when the following conditions prevail:—

1) The imitative species must occur in the same area and occupy the very same station as the imitated.
2) The imitators are always the more defenceless.
3) The imitators are always less numerous in individuals.
4) The imitators differ from the bulk of their allies.
5) The imitation, however minute, is external and visible only, never extending to internal characters or to such as do not affect the external character.

It is noticed that many inoffensive insects simulate the warning colorations of dangerous species. The wasps, bees, hornets, and yellow jackets are recognized by their characteristic display of colors and accordingly are avoided. They are imitated by many flies. Thus the drone

fly mimics the bee. Although the two belong to widely different orders of insects, the one having two wings and the other four, the resemblance is very close. When the fly is on the wing, it even has the same kind of buzzing sound as the bee. This mimetic trait deceived the people of Roman times and led them to the belief that bees were generated spontaneously from the carcass of an ox. It is now known that the drone fly deposits its eggs on such animals.

Ants are not palatable on account of their tough covering and acid flavor. Some of them are even dangerous, possessing, as they do, a sting like wasps and bees. In the Tropics a variety of ants cuts bits of leaves from the trees and carries them to the nest. Very often they are to be seen in great numbers, marching from the trees to the nests, each one with a green leaf in its jaws and hanging over the head and back. In the Amazon basin there was discovered a bug which marched along with the leaf-carriers and imitated them perfectly. The lower portion of the bug's body was brown, like that of the ants, but the upper section was bright green and had the irregular outline of a leaf. Its general appearance was similar to an ant carrying a piece of green leaf. The bug is palatable and if it

were not protected in the way just indicated, it would fall an easy prey to insect-eating animals.

A peculiar form of mimicry is noticed in the larva or caterpillar of the puss-moth. If this caterpillar is disturbed, it pulls back its head into the first body-ring and inflates the margin which is of a bright red color. On this margin there are two black spots in the exact position for eyes and the general impression given is that of a large flat face. "The effect is an intensely exaggerated caricature of a vertebrate face, which is probably alarming to the vertebrate enemies of the caterpillar. The terrifying effect is therefore mimetic. The movements entirely depend on tactile impressions: when touched ever so lightly, a healthy larva immediately assumes the terrifying attitude and turns so as to present its full face toward the enemy; if touched on the other side or on the back, it instantly turns its face in the appropriate direction. The effect is greatly strengthened by two pink whips, which are swiftly protruded from the prongs of the fork in which the body terminates. The prongs represent the last pair of larval legs which have been greatly modified from their ordinary shape and use. The end of the body is at the same time curved forward over the back and so the

pink filaments are brandished above the head." (Poulton.) Accordingly, the caterpillar in its terrifying attitude resembles, in a way, the appearance of a feline form, when irritated.

Another caterpillar discovered in South America by an investigator "startled him and everyone to whom he showed it, by its strong resemblance to a snake and it even possessed the features which are characteristic of a poisonous serpent." The caterpillar of the large elephant hawk-moth acts similarly. It lives on the dead brown leaves of the great willow-herb and can be seen only with difficulty on account of its color, which harmonizes with the background. Two of the body rings have marks like eyes on each side, but they are not conspicuous when the creature is undisturbed. "As soon, however, as the leaves are rustled by an approaching enemy, the caterpillar draws its head and first three body rings into the next two rings bearing the eye-like marks. These two rings are thus swollen and look like the head of an animal upon which four enormous terrible looking eyes are prominent. The effect is greatly heightened by the suddenness of the transformation, which endows an innocent looking and inconspicuous animal with a terrifying and serpentlike appearance. I well remember the start

with which I drew back my hand as I was going to take the first specimen of this caterpillar I had ever seen." (Poulton, "Color of Animals.")

Certain edible and imperfectly protected butterflies give evidence of mimicry. In Africa the female forms of one kind imitate four different species of a protected variety which is unpalatable. The prevailing avoided form of each region is mimicked, and it is only in Abyssinia that the edible female butterfly preserves the primitive features like that of the male.

It is pointed out that only the females display the mimetic characteristics because, as Darwin and Wallace both remark, these forms are in greater need of protection. The males of this particular group are considerably in the majority and their elimination to some extent would not prove serious. However, the females must live longer in order to lay their eggs and thus preserve the species. Again, these females, being loaded down with eggs, are heavier and slower in flight, and during the entire egg-laying period they are exposed to the attacks of numerous enemies. It appears immaterial, whether one of the abundant males is devoured sooner or later, since one male can fertilize several females. But the death of a single female means the loss of

several hundred descendants to the species. The female therefore keeps the species from extinction and she imitates a most ill-flavored and protected butterfly.

Finally a phase might be mentioned which has been called "Simulating Death." This characteristic is so wonderfully manifested by the American opossum, that the expression is often heard, "playing 'possum." The animal has the habit of feigning death when pursued and overtaken. It is said that on such occasions the animal will endure much pain before it will exhibit any signs of life. Some of the beetles with their tough body coverings drop to the ground, when about to be seized, and are uninjured by the fall. They remain motionless where they have alighted and due to protective colorations, it is difficult to see them among the leaves and grass.

Aside from noting the many instances of protective resemblance in color, form, and attitude of various animals, scientists have also endeavored to give an explanation as to their origin. Professor Lull states: "Whatever may be the initial cause of color, its final perfection of adaptation for concealment, warning or whatsoever service it may render, may well be the result of the natural selection factor." Again in the "In-

troduction to Biology" by C. B. and G. C. Davenport it is remarked: "The origin of protective resemblance and mimicry are both explained by the Theory of Natural Selection or Darwinism. Since either of them is of great utility to the organism, their possession even to a slight degree, however accidentally gained, will give their possessor an advantage over its neighbors in the struggle for existence. Consequently it will be more apt to survive and transmit its peculiarity to its offspring. By this means an adapted race will arise and crowd out an unadapted."

The terms "accidental" and "chance" that occur frequently in discussions of this kind are only subterfuges in times of perplexity. Experience will tell us that nothing ever occurs by chance, even though this expression is used so often in ordinary conversation. It may be that the actions of two causes conflict so that the unexpected or what we call an "accident" arises, but all can be traced to certain causes. Similarly the mimetic characteristics are not to be classed among the accidental or isolated cases. They occur everywhere in the animal-world and therefore a cause must be found. To say that they have been accidentally acquired is neither plausible nor scientific. An analagous phenom-

enon was once observed by the writer whilst climbing the Tyrolese Alps. Along the mountain-side and in the valley a heavy mist prevailed, but at the summit there was sunshine and a clear blue sky. From time to time, it could be seen from the coign of vantage that the fleece of the clouds was thrown asunder as if a curtain were drawn back, so that for the moment the city hundreds of feet below became visible. The clouds also gave rise to many fantastic configurations and a person with a vivid imagination could discern weird forms such as mythology mentions. Moreover, they were enhanced by the beautiful blue sky in the background. It could be said that these peculiar outlines were accidentally produced according to a theory similar to that of natural selection. But this play of the clouds was due to causes and was to be traced to physical and meteorological forces.

With regard to imitative resemblances, we are to believe, according to Darwinism, that originally numerous animals appeared with indifferent or disadvantageous colorations. For example, in the beginning the brown rabbit was obliged to flee and conceal itself in the northern climes, on account of its color. The landscape was white due to the prevailing snows, and the animal was

easily detected and destroyed by the indiscernible foe. However, Natural Selection was of assistance, and gradually, the color of the fur was changed from brown to white. At first the offsprings possessed only white patches; later on this color became more prominent, and now the progeny appears like the snowy surrounding. Owing to the great change, the predaceous animals no longer recognized the rabbit, and the latter was able to survive in the struggle for existence. This description is indeed interesting but there are no facts to support it. In fact, no Darwinist has ever told us, except by analogy, what Natural Selection really is or how it operates.

A. R. Wallace writes: "The lion is tawny so as to hide in the desert. The tiger hides himself among the bamboo, so that the vertical stripes with which his body is adorned, will assimilate with the vertical stems of the bamboo."

It could be readily argued that before the lion had acquired his present tawny color, he was compelled to hide somewhere else than in the desert, if he and future generations were to survive. But when Natural Selection made use of the principles of color, light and shade and also the fact that every object in nature, whether

black, white, brown or tawny casts exactly the same colored shade and shadow, the king of the desert gradually acquired the tawny color and sought the desert. There the sun had a chance to cast his shadow and he could crawl behind it and remain invisible to the prey.

Natural Selection dealt differently with the tiger. He received stripes that assimilated with the shadows cast by the reeds. But Huxley reminds us that "the Siberian tiger has a longitudinal stripe down his back." How this could be of advantage to the animal must seem difficult for a Darwinist to explain. Yet one writer says satirically: "The tiger in Siberia, having observed that the Russian convicts who escape, and are hiding, have a longitudinal stripe down their back, modified by the knout, came to the conclusion that, if a Russian convict can hide with that kind of a stripe on his back, so could he.") However, the Darwinist as well as any other evolutionist admits that if man, possessing superior intellectual powers and having many of the elements of Nature under his control, cannot modify his corporeal arrangement, then much less is this ability present in the animal world. Neither the tiger nor other animals can modify their organs, color or traits by the exercise of

any intelligence or will, because their behavior is instinctive. Furthermore, Darwinists disclaim that Natural Selection *causes* anything. But Darwin says that "Natural Selection is intently watching each variation or alteration on its way to perfection and will pick out with unerring skill each improvement and preserve it."

Hence, if neither Natural Selection nor the organisms can be the cause of variations, and these do occur, then there must be some other agent at work. Chance will not explain the problem. It is most improbable to consider, for example, that the spider mentioned above acquired resemblances to the voidings of birds or lizards in shape, coloration, etc., merely by accidental yet beneficial operations. Furthermore, all these animals regularly choose the surroundings that agree with their own coloration; they adhere to objects which afford protection or imitate some peculiar habit of a protected form. All this is done for the purpose of preserving their kind. Since then these changes and modifications in animals are produced for a purpose, the conclusion to be drawn is, that there must be some agent with the power to choose and cause them. This agent cannot be Evolution, because we are told that this is not a cause, but only the name

given to an assumed process. It cannot be Chance, otherwise the lion might have stripes and the tiger a tawny color, whilst the leopard could have remained destitute of spots.

With this objective purposefulness, as seen in beneficial resemblances, there is joined a purposive activity on the part of the animal. Both features are concomitant, otherwise the coloration and the habits would be of no avail to their possessors. They seek the environment, the regions or the company where their protection is assured, just to recall Hippolyte or the bugs living with the leaf-carrying ants. To assert that all these complexities are explained by the Natural Selection factor, does not bespeak a scientific mind in search of true causes and effects. As no mundane agency can be found to adaquately explain these wonderful phenomena, credit for them must be given to the Creator above, who planned them all for the welfare of the individuals. In the various manifestations of protective resemblance and mimicry, there is not accidental adaptation, but purposeful arrangement.

CHAPTER IX

HOW NATURE RESTORES

One of the remarkable powers that the Allwise Creator has given to living individuals, is that of effecting repairs or even replacements, if portions of the body have been injured, destroyed or removed. The loss of a bodily substance, provided it does not cause immediate death, tends to be remedied, either by the reproduction of the lost tissues or by a compensatory overgrowth of other parts. This function varies in the different forms of life. In the higher backbone animals and in man there are some limited manifestations of this power, but it is in the lower animals and in plants that the most marvellous examples occur. With regard to man, it might be mentioned that the outer covering or skin is constantly replaced by younger cells, that are always being formed. This is a fact which does not attract attention because no one is aware of the continual change. However, in time of injury, this power may be realized. The replacing of an injured

finger-nail is more manifest. It has also been noticed how a wound is able to heal and after a time, no trace of injury remains. If the mishap was somewhat more serious, a scar will later be a reminder. But more wonderful is this fact after a surgical operation has taken place, especially if there were internal disorders. The surgical instruments may sever the linings of the body, remove infected portions, even bone, but if the individual can endure the ordeal and if the body can exercise its functions, the person in due time will once more be hale and hardy. It is true that external influence is employed to bring about the healing process, but all the extraneous means would be of no avail, to unite the tissues, blood vessels, nerves, etc., if the person did not possess in his very being, some power that makes use of these various means, or rather is aided by them to readjust disordered parts. The same facts might be stated, to a certain degree, with regard to the animals that have been domesticated by man. Outside aid is employed to further the healing process.

In the world of Nature there are many individuals that meet with mishap and yet their wounds are healed without the aid of man. Many experiments have been made with such

animals to ascertain this fact, not for the sake of seeing them "suffer," but in order to apply the results of these investigations to the welfare of mankind. Many years ago a Catholic priest and scientist, the Abbé Trembley, in the course of his experiments, happened upon a little creature that aroused his curiosity. This was a small form living in the water and is called *Hydra*. In the beginning, he did not know whether to call it an animal or a plant, on account of its peculiar behavior. He knew, as people do now-a-days, that plants can be grown from "slips" cut from a parent form, and the experiment was tried with the *Hydra*. He cut it into two parts and both pieces grew into perfect *Hydras*. When he cut it into many parts they all died. It seemed to be a plant, but when he observed how it procured its food and moved about, he concluded that it was an animal. He thus had made a wonderful discovery, namely, that the power of living parts to grow into entire organisms was a property of animal and plant forms alike. Trembley experimented with these forms in various ways, but they always manifested the power of mending injuries and could live, even though they were considerably changed in aspect. In one case he split the head of the *Hydra* in two and a two-

headed form developed. These heads were again split up to the stage when eight heads were formed. It now appeared like a cluster of roots, but it continued to live.

At a later date, another Catholic priest, Spallanzani, also famous as a scientist, carried on various experiments with different animals, and he too observed this strange phenomenon. He was interested principally in the ordinary earthworms. He cut a worm in two and noticed that the head-portion grew a new tail and acquired the normal size, whereas the tail-part received a new head but remained smaller. A worm that was cut in twain lengthwise did not give rise to new forms. Another observation was made in the salamander, a form that has a backbone. When one of the legs was cut off and the animal was deprived of food for two months, a new leg was formed just as rapidly as in another salamander that had been fed all the while. In another experiment, he removed all four legs and even the tail of a salamander. These limbs were rapidly replaced by the animal inside of three months. This particular observation is noteworthy, because the animal possesses a backbone, and is therefore a creature more highly developed than the earthworm. The animal, besides regenerating 647

new bones to replace the amputated limbs, also supplied new muscles, nerves, and blood vessels, where the original had been removed. Regenerative power is, therefore, possessed to a remarkable degree by the salamander, and the restored portions are similar in every detail to the original limbs. Spallanzani's own remark with respect to the various experiments is significant: "You can mutilate to an incredible extent; you can cut off the jaw, a part of the head, leg or tail again and again from snails and salamanders, and yet each of these types will be produced according to the primitive type. Nature never fails; never makes a mistake; never putting on a fresh kind of leg, head or tail."

Since the days of Trembley and Spallanzani very many experiments and observations have been made by scientists in all parts of the world. A record of them all would fill books. Only a few of them can be cited to show that this power is inborn and could not be manifested, had not a Superior Intelligence made the necessary provisions.

In a form allied to *Hydra (tubularia)* mentioned above, Jacques Loeb, of the Rockefeller Institute, cut off the head and foot-ends alternately and placed it in an inverted position in the sand

of the aquarium. This may have been somewhat disagreeable to the animal but it soon overcame the difficulty by developing a head from the foot-end and vice versa a foot from the head-end which happened to be embedded in the sand. These organisms are so sensitive to polarity that if the position of the entire animal in the water be reversed, even though uninjured, the foot-end becomes changed to the head-end.

Professor Hans Driesch mentions another form, *Clavellina,* which is rather complex and consists of two quite different parts—the one the gill-arrangement and the other the intestinal sac. If the two portions are cut asunder, each can complete itself in a perfect form in three to four days. So far it shows similarities to the worm of Spallanzani. But the gill-arrangement possesses other powers. If cut off entirely, it may lose almost all of the clefts, openings etc., and appear like a small whitish sphere, as if it were deteriorating. After about two weeks, activity is noticed again, and there appears a perfect *Clavellina,* somewhat smaller in size. What really happened was that the gill-portion became a structureless mass, from which developed a reorganized individual. But this is not all. If the separated gill-portion were again cut in two,

the parts thus obtained, in many cases, would become structureless, as happened to the entire gill-apparatus, and each part would become a smaller but full-fledged individual.

The tadpole, the intermediate free swimming stage between the egg and full grown frog, furnishes another example. Spallanzani long ago recorded that it could restore its tail if the original were cut off. Even if a part of the new tail were cut off, the missing portion would be regenerated. In one instance, the tail was removed and the animal was kept without food. Although the tadpole did not grow larger as a result of the deprivation of food, the missing tail was replaced. All four legs of another tadpole were amputated, but in time others appeared.

In the above cases, scientists were instrumental in removing portions of the bodily forms of individuals and noted the outcome. But there are other instances where persons are not concerned in the removal of parts and yet the same phenomena exist. Some animals, in a rather strange manner, surrender their limbs and at a later date have them replaced. This occurs among lizards. In time of danger or injury they are able to cast off the tail of their snake-like bodies. As they hasten along, the pursuers usually endeavor to

seize them by the tail, and if this happens, the animal simply snaps it off and by the time the foe has recovered from the surprise, the lizard has escaped. This group of animals possesses a backbone, and scientists upon investigation discovered that from the seventh tail-vertebra on there exist special breakage-planes, or grooves, where the detachment takes place. From such a plane outward the new tail is regrown.

The animals without a backbone manifest this power more remarkably. Take, for example, the lobster and its allied forms. The lobster has two large claws in the front part of the body. As can be readily seen, they are not alike, the one being arranged for crushing and the other for cutting purposes. The crushing-claw may be either on the right or the left side of the individual. The lobster, crawfish, and crab have the power of throwing off their powerful limbs if they are injured or seized by the foe. New claws will eventually be developed. These animals also possess a breakage-plane, namely, a groove, into which the skin is continued in the form of a membrane. After the lobster has thrown off its leg, the smooth, skin-like surface is seen, with just a small opening in the centre, where the nerves and blood vessels had continued to the portion

given off. This opening, however, is quickly closed by a clot and loss of blood is prevented. Should the limb be snapped off at any other point, the loss of blood would be considerable and in some cases the animal would bleed to death.

The process involved in the surrender of the claw is of interest. It is the result of a reflex nervous act. If, for example, a person should touch a very hot object with his finger unknowingly, the finger is quickly withdrawn, before there is any time for reasoning. This is due to an involuntary act and no deliberation is demanded. A nerve conveys the impulse from the heated object to the central nervous system, and immediately a message is sent back by way of another nerve, which causes a muscle to contract suddenly, so that the finger is removed. A similar process is employed by the lobster. If the claw is held tightly or injured, a message is sent to the ventral nerve cord, and from this point an impulse is conveyed to the muscle of the leg. The muscle contracts with such violence that the leg is broken off.

Even under ordinary conditions, the lobster might lose its claws quite frequently. These limbs are rather heavy, especially in the male form, and the breaking joint is quite small in

comparison. So it may happen that if the animal is out of the water, the weight of the leg would cause it to break off. When lobsters are taken out of the water or from vessels bringing them to the markets, or even if the claw be held firmly by another lobster, the same very often happens, because they endeavor to escape danger. The fact of surrendering the limb is remarkable, but the arrangements inside the base of the leg consisting of the bandaging flaps is of equal importance. These close and with the clot prevent loss of blood. Furthermore, beneath the scar, which forms at the breaking point, a bud-like structure develops, which in time becomes a new leg in miniature. When the animal next "sheds its skin," the newly formed leg straightens out and by increasing in size at subsequent moults, it ultimately appears as a full-grown claw, similar in every detail to that which had been cast off.

The five-armed starfish, in its dry and hardened condition, is an object of interest in many homes. When living, this also possesses remarkable regenerative powers. Like the lobster, when endangered or injured, it can surrender its arms. It may even break off all five arms in succession, if necessary, so that only the central portion or disc remains. From this, new arms

will be developed, as long as the originals. No record, however, has yet been given of a single arm producing an entire star-fish, although it has been observed how a perfect individual was formed from an arm that still possessed a small portion of the central disc.

In the forms called brittle-stars, the arms seem capable of detachment at any point. The break may occur very close to the part that is held or pinched. If the portion adhering to the body is again seized, another fragment is surrendered and in this manner the entire arm may be detached, piece by piece, up to the central disc. All these arms can be regenerated.

An interesting specimen among the worms is the palolo worm, which has as its habitat the coral-reefs. At breeding time, the head is somehow completely separated from the body and this latter portion sets free thousands of minute germ cells into the water and then dies. However, the severed head remains concealed in the rocks and provides itself with a new body.

In time of danger, the sea cucumber ejects its insides and makes its escape from the surprised enemy. On account of its peculiar activities on such occasions, it has also received the name "Cotton-Spinner." If molested, it causes the

muscles of the body-wall to contract and these then press on the liquid in the body cavity. The viscera are thereby discharged and when they come in contact with the water they split up into a meshwork of white threads. The enemy may accordingly become entangled in this "cotton." In one case a lobster was observed to be so completely enmeshed as to be unable to move. That this procedure does not prove fatal to the sea cucumber, is seen from the fact that after about ten days all the organs are again replaced.

In the spider group, there is one individual called the daddy-long-legs, harvestman, or *phalangid,* which possesses very long legs. In the autumn it darts swiftly among the herbage in search of small insects, which it kills and sucks, or else it goes in quest of refreshment, that the dew drops provide. Any one who has caught such an animal, is aware of the fact, that it surrenders its lank legs almost instantaneously and runs away. A scientist relates that he once saw a harvestman "running with very fair speed and facility, having lost all but two legs, an anterior one on one side and a posterior one on the other." This is another example of an animal that is able to part with its limbs and to have them replaced in subsequent moults. The same may

be said of various insects, such as the "walking-stick," which, besides casting off its leg at a definite breaking joint, can regenerate new limbs.

Aside from the extraordinary instances of surrendering and regenerative powers mentioned thus far, there are other phases of replacement which occur quite regularly in many animals. A typical example again is furnished by the lobster. As is well known, it possesses a hard outer covering which protects it and gives support to the internal organs. The shell is also a point of attachment for the muscles, by means of which it moves. In a way it answers the same purpose as the skeleton of creatures with a backbone. This outer covering is continuous over the entire body and limbs. It is composed of a horn-like substance called chitin and, for the most part, it is hardened by different salts of lime. However, at the joints it is thin and soft, so that the parts can move one upon the other.

Since this outer covering is not elastic, there is no opportunity given to the animal to extend itself during growth. The difficulty is overcome by the animal shedding its entire skin from time to time, which process is known as moulting. About five weeks before the covering is to be cast off, there are to be seen in the food-canal, sheets

of calcified chitin, which eventually are formed into smooth flat stones. Before the moult actually occurs, these stones are given off into the cavity of the stomach and are reduced to fine particles by the grinding apparatus found there. As the stones are like the substance of the outer covering, it seems that they have been derived from it. It is furthermore observed that in the region between the middle and hind parts of the body, lines appear, along which the covering is to split. Similar lines of varying length and extent appear along the various limbs. So it may be that the lines are prepared and rendered weaker and less resistant by the removal of the calcified chitin into the food-canal. How the process is carried on by the lobster, is not yet understood by biologists. When the moulting takes place, the covering breaks open along the various lines and the body and limbs are gradually worked loose within. Then, through the main opening the lobster withdraws, first the fore part of the body with the limbs and later on the hind part. The old covering with all its appendages is abandoned in almost perfect form. In the meantime the animal has provided itself with a new skin, which at first is very soft, and for about six weeks it is helpless against the

attacks of other animals. Very often it happens that the unprotected crustacean falls an easy prey to the predaceous fish (sharks, skates, and cod) that feed upon it. After moulting, the lobster is, therefore, in great need of lime to harden the shell and it has been noticed that for the purpose, it frequently devours its own cast-off skin. By way of interpolation, it might be mentioned that a similar process goes on in the crab and therefore the "soft shell crabs" are individuals that have cast off their old covering and do not as yet possess the new one in a stiffened condition. Young lobsters are said to moult twice a year, so also do the adult males. A creature about two inches long has shed its skin about fourteen times, a five inch individual, twenty times and when ten inches long about twenty-five times. Roughly speaking, a ten-inch lobster is about four years old.

Another group of individuals that show peculiarities in moulting, is that of the woodlice. They seem to live chiefly on vegetable food and at times they do great damage to seedlings and tender garden plants. Some of them live as guests in the nests of ants. When the moulting period arrives, they do not abandon their entire skin at once. On the contrary, they escape from

the hinder part first, and only after two or three days, when the new skin has hardened, do they cast off their front part. Thus it happens, that these woodlice go about with the front part of the body of one color and the hind portion of another hue, because the moulting has not yet been complete.

The spider shows a different method of moulting. Up to the time that the first shedding of the skin takes place, this creature can neither feed nor spin, because the mouth and spinning tubes are clogged by a membrane. In this stage it is pale-colored and it has less hair and spines than in the mature form. The first moult occurs when the spider is still with the rest of the brood either in or near the egg-bag. When the time comes for the first escape, it holds on to the flossy nest with the front and third pairs of legs. The hind legs are drawn upward and forward and these seize the sac-like shell which covers the body. The feet push the shell downwards while at the same time the body is drawn upwards, until the spider is liberated from the skin. In the subsequent moults the process is changed. The creature collects its legs together and attaches them with silk to the upper side of the web. The body is also attached, but hangs below. The old

skin covering then splits along the sides of the body and the spider, by incessant and violent wriggling, frees itself. It leaves behind a complete cast, including the legs on the upper side of the web. In the two days preceding the moult it takes no food and for fifteen minutes after the process, it hangs in an apparently lifeless condition, until the new skin has hardened. If the spider had been without any of its limbs before the moult, substitutes appear afterwards. But if endeavoring to escape from its old covering, any limbs are broken off, the new ones will not be forthcoming until the next time that it casts off its skin. In the different species of spiders, there is a difference with regard to the number and recurrence of the moults. One form sheds its skin nine times after leaving the egg shell, once within the first two months and thereafter about every three weeks.

Among the insects, moulting is also of frequent occurrence. For example, when the butterfly is still in the caterpillar stage, it causes the skin to become detached from the body by the action of an intervening liquid. The skin dries up and shrinks. By contracting its body, the larva effects an opening near the head, from which point it crawls out. The old skin is pushed

back toward the tail until the entire covering has been left behind. This process is repeated, until the caterpillar has reached full size, at which time it enters the cocoon stage.

The ordinary house mosquito undergoes moulting in the early stages of its existence. In a day or two after the eggs are laid, there emerge tiny larvae, commonly called "wrigglers," from their peculiar motion in the water. In this stage, which usually lasts about a week, the mosquito feeds on minute plants and animals found in the stagnant water, and grows rapidly. This state of affairs necessitates the shedding of the outer covering and the formation of a new and larger skin. During this time the mosquito appears somewhat like a worm. Later it enters the third or pupa stage, when the sucking mouth-parts, the long slender legs, and the delicate wings are developed and can be seen through a transparent outer covering. When the development is complete, it moults again and the insect leaves the pupal case in the water and flies into the air as a mature mosquito.

Birds as a rule moult their feathers at least once a year, often twice, and in some cases even three times. The wing-quills and the tail feathers are usually given off in pairs. But

swans, geese, ducks, and flamingos shed all the wing feathers at one time and for a while they are incapable of flight. Some birds of the auk group discard the horny parts of the beak. Snakes shed their entire outer covering even including the portion that runs over the eyeball. The mammals "lose their hair" at least once a year.

In conclusion, an interesting example may be taken from the plant-kingdom. When the work of the summer is over, it is to be observed that the leaves fall from the trees and plants, and preparations are made for the winter. In the tropical countries, the leaves remain attached for long periods, but in the temperate zones this can only be said of the "evergreens." The severe winters and the snowfalls prove detrimental to the other plants, and for better protection the annual dropping of leaves takes place. In the autumn, the valuable materials in the leaf are absorbed by the branches and roots, with the result that the foliage changes its color. Across the leaf-stalk, which in summer is firm and tough, there now grow soft spongy cells, which multiply and expand to form a separating layer. These delicate cells may become changed into cork cells, or they may arrange themselves in such a way to

permit water to collect between them. The leaf is now only lightly attached and in the case of the cork cells, the least gust of wind would cause it to break off readily. In the other case, if the water in the intercellular spaces should freeze, an expansion takes place and the remaining cells would be snapped off. This brings about the fall of leaves as seen on certain mornings after a frost. At the place where the leaf had been attached, a waterproof scar is visible, produced by the cork cells or by the drying up of the other kind of cells. In this manner, the waste of sap is prevented and no living forms can gain admission for the purpose of attacking the bark and bringing about decay. The trees and plants that shed their leaves are not endangered by this process. In fact, they are benefited, since the fluids are preserved within them and the bare branches, protected by the durable outer covering, resist the cold, and in many cases they offer very little landing place to the snow that may fall upon them. With the advent of Spring, new leaves make their appearance and their characteristic and important functions are once more in evidence.

Accordingly, there is in living creatures a remarkable power, which enables them to make

repairs and even reconstruct portions of the body that must be renewed or have suffered harm in one way or the other. However, there is this limitation: in the case of injuries, there must never be such grave seriousness as to result in death. But even here the living organism will endeavor, to the last moment, to use its forces and bring about restoration. Wonderful as is this power, it cannot be fathomed and by no means should it be considered a matter of course. Some would tell us that at the present time it is part of the inborn make-up of creatures to behave in this manner. Professor Weisman remarks concerning such phenomena: "This also appears to us to be adaptive and does not surprise us, since we have long been accustomed to recognize that what is adapted to an end, will realize this, if it be possible at all." We are also told that it must have taken ages for living beings to bring about these perfections, especially when we consider the special and intricate arrangements as found in breakage planes, etc. It is the Darwinist who would hold that all these arrangements were developed gradually throughout innumerable ages and that they are due to chance, i. e., that no guiding principle was at work. Step by step, these various provisions are believed

to have come about through some kind of mechanical action. But in all these processes there was no plan to be followed, there was nothing to guide the work of Nature. Darwin in his Autobiography tells us: "The old argument from design in Nature . . . fails now that the Law of Natural Selection has been discovered. . . . There seems to be no more design in the variability of organic beings and in the action of Natural Selection, than in the course the wind blows." Thus, for example, the breakage planes in lobsters, lizards, and the process whereby a leaf is able to fall in autumn—just happened to be developed by something. In the course of ages and ages, accidental modifications set in, and at the present time they prove to be of great advantage to the possessor. But this is erroneous speculation and, in the last analysis, runs contrary to reason and experience. Though it is true that adaptations occur in Nature, these can never be due to chance, even as Darwin interprets it. There is a guidance in everything, even though at first sight it may not be apparent. If this line of argumentation be employed, then all the various arrangements in the world, the works of art, etc., have been brought about in the same manner. The Duke of Argyll states: "It would

be just as rational to account for the poem of the Iliad or of Hamlet, by supposing that the words and letters were adjusted to the conceptions by some process of Natural Selection, as to account by the same formula for the intricate and glorious harmonies between structure and function of organic life." Credit for these wonderful arrangements and provisions in man, animals and plants must be given to a Superhuman Intelligence that has endowed living creatures with the remarkable powers. Any other line of reasoning, starting from a different "point of view," is false and dangerous.

"The example of the great apostle of evolution himself should warn us as to this. Darwin, as he sits in marble on the staircase of the British Museum, represents a noble figure, made in the image of God and capable of grasping mentally the heaven above as well as earth beneath. As he appears in his recent biography, we see the same man paralyzed by a spiritual atrophy, blinded and shut up in prison and chained to the mill of materialistic philosophy, where, like a captive Samson, he is doomed to grind all that is fair and beautiful in Nature, into a dry and formless dust. Would that he had lived to pull down the temple of Dagon with his own hands,

even if an ephemeral reputation had perished in the ruins, and to avenge himself of cruel enemies that had put out the eyes of his higher Nature." ("Modern Ideas of Evolution" by Sir J. W. Dawson.)

CHAPTER X

THE LOCUST IN ANCIENT AND MODERN TIMES

AMONG the few insects known to mankind since the days of great antiquity, the locust reserves to itself the right to a very prominent position. It was considered a certain vile insect by the peoples of old, and attention was drawn to it principally on account of the baneful effects resulting from its activities. This insect occasionally influenced the economic conditions of the past, and hence frequent reference is made to it in the writings and utterances of the ancients, either in literal or figurative language. In the Holy Bible, some seventeen Books of the Old Testament mention characteristics connected with this insect, while in the Books of the New Law it is referred to in three different writings. The observations made and recorded in the Sacred Text are so remarkable that, in the main, the results of present-day scientific investigations can act only as a complement to the facts cited.

The appellations of the locust, of frequent occurrence in the Hebrew Text, are *arbeh*, the root of which means to multiply, and this word is descriptive of the fecundity of the insect. The word occurs twenty times. Then there is the name *chagab*, for "locust" or "grasshopper," the latter interpretation being applied because they were locusts that chirped like grasshoppers. Another term is *gehim*, also translated either as "grasshopper" or "locust." So too, the word *solam* refers to the edible leapers, and *hargol* is interpreted "galloper."

For the sake of elucidation, some of the striking passages of the Old Testament might be mentioned. The first reference to the locust is found in the Book of Exodus (x, 3-6) and is as follows: "Therefore Moses and Aaron went in to Pharao and said to him: Thus saith the Lord God of the Hebrews: How long refusest thou to submit to me? let my people go, to sacrifice to me. But if thou resist and wilt not let them go, behold I will bring in tomorrow the locust into thy coast: To cover the face of the earth that nothing thereof may appear, but that which the hail hath left may be eaten: for they shall feed upon all the trees that spring in the fields. And they shall fill thy houses, and the houses of thy

servants and of all the Egyptians: such a number as thy fathers have not seen nor thy grandfathers from the time they were first upon the earth until this present day."

Ibid., x, 12-15: "And the Lord said to Moses: Stretch forth thy hand upon the land of Egypt unto the locust, that it come upon it and devour every herb that is left after the hail. And Moses stretched forth his rod upon the land of Egypt and the Lord brought a burning wind all that day, and night: and when it was morning, the burning wind raised the locusts: And they came up over the whole land of Egypt: and rested in all the coasts of the Egyptians innumerable, the like as had not been before that time, nor shall be hereafter. And they covered the whole face of the earth, wasting all things. And the grass of the earth was devoured and what fruits soever were on trees, which the hail hath left: and there remained not anything that was green on the trees, or in the herbs of the earth in Egypt."

Again, verse 19: "And he [the Lord] made a very strong wind to blow from the West, and it took the locusts and cast them into the Red Sea: there remained not so much as one in all the coasts of Egypt."

A poetical description replete with pathos and faithful touches is given to us by the Prophet Joel (ii, 1-11): "A day of darkness and of gloominess, a day of clouds and whirlwinds: a numerous and strong people as the morning spread upon the mountains the like to it hath not been from the beginning, nor shall be after it even to the years of generation and generation. Before the face thereof a devouring fire, and behind it a burning flame: the land is like a garden of pleasure before it, and behind it a desolate wilderness, neither is there any one that can escape it. The appearance of them is as the appearance of horses, and they shall run like horsemen. They shall leap like the noise of chariots upon the tops of the mountains, like the noise of a flame of fire devouring the stubble, as a strong people prepared to battle. At their presence the people shall be in grievous pains: all faces shall be made like a kettle. They shall run like valiant men: like men of war they shall scale the wall: the men shall march every one on his way, and they shall not turn aside from their ranks. No one shall press upon his brother: they shall walk every one in his path: yea, and they shall fall through the windows, and shall take no harm. They shall enter into the city: they shall

run upon the wall, they shall climb up the houses, and they shall come in at the windows as a thief. At their presence the earth hath trembled and the heavens are moved: the sun and moon are darkened and the stars have withdrawn their shining."

The people are threatened with the approach of locusts in Deut. (xxviii, 38), whilst in III Kings (viii, 37), II Par. (vi, 28) (vii, 13) and Psalms (LXXVII, 46) (CXLIV, 34) these insects are mentioned as a plague and punishment.

Their flight and activity are used for comparison in Job (xxxix, 20), Proverbs (xxx, 27). Ecclesiasticus (XLiii, 19) and Joel (i, 4). They disappear suddenly, Nahum (iii, 17) and have a gregarious instinct, (Isaias, xxxiii, 4). Individually they are insignificant, (Numbers, xiii, 34; Isaias, XL, 22) and feeble, (Psalms, cviii, 23).

The traits of the locusts are also used to describe an invading army (Judges, vi, 5 and vii, 12), where it says: "But Madian and Amalec, and all the Eastern people lay scattered in the valley as a multitude of locusts." In the Book of Judith (ii, 11), there is related concerning Holofernes: "He went forth, he and all the army, with the chariots and horsemen and archers who covered the face of the earth like

locusts." Finally Jeremias (xLvi, 23) prophecies against Egypt saying: "They have cut down her forest, saith the Lord, which cannot be counted: they are multiplied above locusts and are without number."

The above passages and references show that the locust was well known to the people of old, in Egypt, Palestine and the neighboring countries. Brogniart opines that related forms even existed in abundance during the great Mesozoic Era, especially the Carboniferous Period, long before the appearance of man upon this earth. However the fossil remains do not prove this conclusively as they are fragmentary and obscure.

Not only in Biblical times, but also thereafter, even to the present day, has this insect appeared not infrequently in various countries of the two hemispheres and has always effected some harm.

The name "locust" has been erroneously employed in popular language and does not convey the idea of the individual that taxonomists give in their zoological systems. In this country, the term ordinarily refers to the periodical Cicada or "Seventeen Year Locust," a form well known by its shrill, trilling note. This remains underground for a very long time and only ap-

pears on the surface of the earth in full growth, every thirteen to seventeen years. Similarly, the word "grasshopper" has been applied to certain species of true locusts, although the true grasshopper, together with the katydid, belongs to a different subdivision of insects.

True locusts are to be classed under the *Acridiidae,* a family of the leaping *Orthoptera* ("straight-winged"). The *Acridiidae* are so named because they feed on *"ta akra," i. e.,* the tops of the ears of corn and plants. They receive the name *Orthoptera* on account of the peculiarity of their two pairs of flying organs, which differ in outline and construction. The first are long, comparatively narrow structures of a firm parchment-like texture and are marked off with several longitudinal veins, which divide beyond the middle so as to become more numerous as they reach the extremity of the wing. Furthermore, this wing-organ shows a great network of nervures, which gives to the surface the appearance of an aggregation of numerous small cells. These organs are known as the wing-covers or *elytra,* from the Greek word meaning "cases."

The hind wings are larger, of more delicate texture and more flexible. They also possess

longitudinal veins which however bifurcate but little. Numerous cross veinlets are also present in these wings. When at rest these structures fold together like a fan and are entirely concealed by the *elytra*. The longitudinal folding and the position of the wings when closed have given the name *Orthoptera*, "straight winged," to the Order, to which the locust belongs.

The locust is protected by an external horny skeleton, which is generally reddish-brown, or dull-green, in color. This integument exhibits a series of constrictions, dividing the body into rings and these rings are grouped into three regions separated by a soft, pliable membrane. The front region is the head, the enlarged middle portion is called the thorax and the posterior end, the abdomen.

The head is large and bent abruptly downward in front, or even inward, so as to be placed in a plane at an acute angle with the vertex. To the head are attached the antennae or feelers, outgrowths, that are usually shorter than the body. Rather far apart, at the sides of the head, are two conspicuous eyes, that are compound in structure. In the young form, the eyes are not composite, but in their place exist simple organs of vision, which during the growth of the em-

bryo, increase in number and finally unite to form large, many faceted, visual organs. Experiments have been performed to ascertain the exact mode of functioning proper to such a compound eye. Some investigators maintain that the insect has "mosaic vision," according to which, each facet or unit of the organ perceives only a portion of the object, so that but one image is produced. Others aver that each facet sees the entire object, so that many images are thus recorded.

To the large middle region are attached the wings already referred to, and three pairs of legs. The front and middle legs are similar and small, while the hind legs are quite large. The thighs of the latter are thicker toward the place of attachment and are generally peculiarly sculptured, by having long ridges and grooves, and being frequently marked with short parallel lines, which meet a longitudinal line running along the centre. The tibia or lower part of the leg bears two rows of spines on the upper side. By means of these legs the locust is able to leap from place to place. Aristotle, in *"De Partibus Animalium,"* says in this connection: "They first bend, then extend their legs, and by doing so, are necessarily shot up from the ground.

Only the hind legs resemble the steering oars of a ship. For this requires, that the joint shall be deflected inwards. The whole number of legs, including those used in leaping, is six in all these insects."

The Prophet Joel (ii, 5) speaks of a trait, "like the noise of a flame of fire devouring the stubble." This statement is referable to the peculiar sounds that the different species of locusts are able to produce. The mechanism for such sound productions differs conspicuously from that which produces the "voice" in vertebrates. There are no lungs or breathing apparatus comparable to that of beasts or birds, because in these it is an internal arrangement. The locusts, however, produce sounds or music in a rather remarkable manner. One species has high pitched and somewhat strident notes, that are produced by rubbing the roughened inner surface of the hindmost thigh, possessing a row of bead-like projections, against the outer surface of the wing case, which is especially enlarged and has a sharp edge. Accordingly, the wing cover serves as a kind of "fiddle" and is thrown into a state of vibration, so that the musical sound is heard. Other forms are said to use only the wing-cases for this purpose. One of these covers bears a

file, the other a sharp edge. By slightly tilting the wing-cases and vibrating them rapidly, the sharp edge passes under the file with the result that a crackling sound is emitted.

The music, produced by different species, is reported by experts to be remarkably uniform. One kind gives forth about six notes per second and continues them from one and one half to two and one half seconds. Another locust makes from nine to twelve notes in about three seconds. In both cases the notes follow each other uniformly and are slower in the shade than in the sun.

Situated a little over the hind leg, are organs which have the semblance of "ears" and are supposed by many to be organs of hearing. They are modified portions of the skin and produce a sort of drum. On the inner side they are connected with structures having the appearance of rods, which lead to a group of nerve cells and from these there is established a connection with the brain. It is supposed by those, who hold that these organs are ears, that when a wave of sound strikes the tympanum, the vibrations affect the rod-like organs and are eventually transmitted to the brain. So, perhaps, the different individuals are able to recognize the distinct stridula-

tions produced by members of their own species. Whether the locusts perceive the stridulations as sounds has not been proven. One scientist thinks that they are felt rather than heard. They are vibrations—"felt as in a cathedral we feel the vibrations of the organ-pipes in the bones of the chest and head or on the covers of the hymn-books in our hands"—and may have the purpose of keeping the insects together.

Another observation made in connection with these insects when in flight, is that, at times, the wings appear motionless and the creatures seem to float in the air. This is ascribed to the sustaining power of the wing surface, but mainly to the fact that the weight of the locust is lessened by the prevalence of dilated sacs in the interior of the body. Since an individual insect is of considerable weight, it is more than probable that a true flight can only be accomplished when these sacs are inflated, and through the buoyancy of the heated air which they contain, the lightness of the body is increased. By what process dilation is accomplished, is not exactly known. In the Rocky Mountain locust of our own country there are two sets of sacs, the one being a thoracic group—a pair of very large size—connected with smaller ones in the head. Then

there is an abdominal set, which forms a very remarkable series. Besides, there are present many dilatable tracheae or air tubes, where there is no space for air sacs. Hence, the locust is able to fly by means of its own wing power, or be sustained in the air by the inflated sacs so that the wind may carry it along.

The egg-laying process of these insects is also an item of interest and importance. The female member possesses at the extremity of the abdomen hard structures in the form of plates which are suitable for digging purposes. By means of these it excavates a hole in the ground where the eggs are to be deposited. The place selected is dry soil on high ground, as, for example, vineyards, gardens, and warm hillocks covered with grass and bushes; also pastures and dry localities just outside of forests. Some species even make holes in fence-rails, logs and stumps. High dry soil is selected, because the lowlands prove detrimental, on account of the prevailing dampness, which would cause the eggs to mould. Here again, the Stagirite, "*Historia Animalium,*" remarks: "The eggs are subject to destruction by the autumn rains, when rains are unusually heavy. In seasons of drought locusts are exceedingly numerous, from the absence

of any destructive causes." The ovary of a female locust contains between 130 to 150 eggs, and these are deposited in lots of 25 to 50. With the eggs there is also deposited a quantity of fluid, which in time hardens and forms a protection for them. When the egg-laying function is complete, but little trace is left to mark the place of deposit.

The time of oviposition is, in general, from August to October, and in some countries even later. As the eggs are laid at different times, especially if the insect is migrating, it means that the offsprings make their appearance in successive periods. The mode of escaping from the protective mass has also been observed in some species. The young forms creep out of the capsule from the end of May to June of the following year. One species was noticed to put into action an ampulla—a dilatable membranous sac—existing between the head and middle region. The ampulla is thought to be inflated by a fluid coming from the body cavity. Six or seven imprisoned locusts will dilate their ampullae at one time and then combine their efforts to break and push off the protective covering. Later, the sac serves as a kind of resevoir, by the aid of which the insect can diminish other parts of the

body, which, as Fabre says, are almost like a fluid, in order to emerge from the capsule and then penetrate the cracks in the earth, so as to reach the surface. Moulting occurs immediately after leaving the egg-case. The ampulla reappears at subsequent moults and enables the insect to burst its skin and escape from it. The species prevalent in the western part of the United States breaks the egg-shell by an abrading action of the spines on the tibiae against the covering.

Immediately upon leaving the egg-case, the young locust after having cast its skin, displays a clear, green color. This rapidly becomes brown and in twelve hours, is black. It is a small, weak form, scarcely noticeable and remains in sandy indentations and dry ditches, to protect itself against the weather. In about six days it undergoes a second *ecdysis* or moult, after which it is black in the main, though spotted and banded with white and rose color. Some six or eight days later, there is a third moult, when the rose color is more pronounced and the head is brownish instead of black. Eight days after, the insect sheds its skin again and the rudiments of the wings appear. During this period, it is quite voracious. In ten days it experiences a

fifth *ecdysis* and the hind body greatly increases in size. After fifteen or twenty days, the sixth moult occurs and now the insects appears in perfect form. These facts were obtained by observing the species *Schistocerca peregrina* prevalent in North Africa and probably one of the plagues of Egypt.

A prominent fact in connection with certain species of the *Acridiidae* is that they have the migratory instinct, but although such individuals are found in many parts of the world, investigations show that there are only about one dozen of the migratory kind, some of which are the following:

Caloptenus-femur-rubrum—the common red-legged individual, which at one time was so abundant in New England and Canada as to become a public calamity; not, however, in late years. It is a widely distributed species ranging from Labrador to the Mississippi.

Caloptenus spretus or "Rocky Mountain Locust." This appears in immense numbers in the region between the Mississippi and the Rocky Mountains and from Saskatchewan to Texas. The native breeding place of this insect is therefore an area of some 300,000 square miles covering the territory of Wyoming, Montana, and Canada north of Montana. This locust resembles *Caloptenus-femur-rubrum*,

except that it has longer wings. In times of excessive drought it leaves its native breeding place and travels southeast into the lower and more fertile regions of the Mississippi Valley, where it does great damage. At one time it almost produced a famine in Kansas and the neighboring States. The young of this insect, that happen to be hatched in the lowlands, are not healthy and die before reaching maturity. Hence the plagues caused by their migration are of short duration. This is the chief migratory species of North America.

Pachytylus cinerasceus is widely distributed in the Old World. Its territory extends from the Madeira Islands to Japan, thence over the Fiji Islands to New Zealand, northward over Northern Australia to Java, Mauritius and Northern Africa to Kartum. In this vast territory the insect is annually found in one stage or another of development and is also quite migratory.

Caloptenus italicus is prevalent in Spain, Southern France, Italy, Southern Russia, Siberia and even Algiers.

Stauronotus cruciatus exists in Southern Russia, Asia Minor, Cyprus and Algiers.

Schistocerca peregrina is the chief migratory species in Northern Africa.

Pachytylus migratorius seems to be limited to Turkestan and Eastern Europe.

Districts subject to invasion are not visited every year by these migratory species. In fact,

such visitations may be renewed only after long intervals of time. The reasons given for the migrations are various. It may be the lack of food at times when great numbers of superfluous individuals are produced. So also, climatic conditions may have some effect, as the eggs may remain in the ground for more than a year and only hatch out when a favorable season occurs. Again, they are said to be due to the instinct of finding a suitable place for the progeny, *i. e.*, warmth for the eggs and food for the immature locusts. However, one important reason seems to be that the insects are molested by parasitic individuals, and seek to escape the torture. The Russian scientist Rossikow undertook investigations and found two groups of parasites that prey on the locust.

One species of the family *Sarcophagineae,* "flesh flies," place their newly hatched progeny on the bodies of the older nymphs and mature forms of the locust. The parasites then bore into the bodies of their hosts, consume the fatty masses and internal organs, and eventually effect their destruction. Rossikow proved that in one case these parasites destroyed a swarm of locusts in fourteen days. Then there is a species of mites that lives upon the body of this insect. Some-

times there are about five hundred mites on one locust. The tortures caused by both parasitic forms are thought to be the chief reason for the great flights of this creature. It is significant, too, that only the older nymphs and mature forms are affected, not the young undeveloped individuals.

Although several species of locusts are migratory, not all of them leave their native breeding places in great swarms. For example, there is a migratory species always present in Belgium, but it never migrates in "vast armies." However, some facts might be mentioned to show that great swarms have been prevalent even in our own day. These forms evince remarkable manifestations of instinct. Several generations may have passed without any migration occurring, yet a group, when migrating, will go in the direction of the home of its predecessors. The movements depend to a large extent on the wind. Hence, trial flights are first made to learn the direction. When on the wing, there is probably very little muscular effort, as the inflated air sacs keep them aloft and the wind carries them along. Should the wind become unfavorable, they alight and wait for a change. When a swarm comes to the ground in any locality, all devour the leaves and

fruits, the female members deposit a number of eggs, and then proceed in their course. After a season or two, few or no locusts may be present in such a locality. This may be due partly to the lack of food after hatching, so that the young individuals died, or it may be that the insects, after full growth, migrated back to the land of their ancestors, as has been observed in the United States.

The gregariousness of locusts was observed in Europe between 1754–1757. During that period they had so multiplied as to cover the entire Iberian Peninsula. The insects devoured all kinds of plants and did not even spare the poisonous variety. Even linen and woolen clothes, that had been hung out to dry, were eaten. In 1780, the insects were so numerous near Zomora, in Spain, that three hundred persons were engaged for about three weeks in sweeping together the bodies of dead locusts and the number of bushels thus collected amounted to over four thousand.

In Eastern India a yellowish-red species once appeared in such multitudes that they were spread out some five hundred miles in the air and the swarm was so dense that it shut out the light of the sun, and caused monuments at a distance of

170 yards to become invisible. A traveller by the name of Temple while living in Peru observed one evening that at some distance from him the landscape seemed to have a peculiar color. It was not the green of the grass and foliage but rather a reddish-brown just as if the sun were shining upon a pasture. The color, he soon discovered, was due to the presence of locusts, that had covered the earth, the trees and bushes, as far as he could see. The branches of the trees were bent under the weight of the numerous individuals. He then proceeded to travel right through the invaded area and his impeded progress took over one hour.

In November, 1899, a flight of locusts passed over the Red Sea. The swarm was said to have been about two thousand miles in extent and it was estimated that the group weighed about 42,850 millions of tons, each locust weighing about $\frac{1}{16}$ of an ounce. The following day another swarm, thought to be even larger, passed in the same direction.

Official accounts in Cyprus for the year 1881 record that up to the end of October of that year, 1,600,000 egg-capsules had been collected and destroyed. Since each egg-case harbored a number of eggs, the total weight of the eggs

collected and destroyed, must have amounted to about 1,300 tons. Nevertheless, in 1883, some 5,076,000 egg-cases are believed to have been deposited on the island by the offsprings that survived.

Such swarms are indeed surprisingly great, but the destruction caused by these insects is also a matter for serious consideration. It is said that in Arabia they devour the corn when it is ripe and what they do not eat, is infected by their touch and by the moisture coming from their body.

A certain Dr. Linecum describes the ravages of *Coloptenus spretus* in Texas. The young escaped from the egg coverings in early March, and by the middle of the month had destroyed one-half of the vegetation, although they were very small and wingless. The first winged specimens were seen in the air one day at 3 P. M. A light northerly wind arose and they dropped to the ground in millions and began to destroy everything green. During the night they remained quiet, but with the break of day they began to eat again and continued their destruction until ten o'clock in the morning, when they took to the wing and flew southward. At three o'clock that afternoon, another horde arrived, ten times more numerous than the first. These left

the place on the following afternoon. This procedure continued day after day, new swarms appearing and depositing their eggs and devouring all kinds of vegetation. Their visitation spread over many hundred miles.

Reliable accounts are given by persons travelling in Africa and America. Adanson, in 1750, came to the River Gambia in Africa. Whilst traversing the stream, around 8 o'clock one morning, he noticed a thick cloud, which darkened the heavens. This cloud was in reality a swarm of locusts, flying some ten to twenty yards above the earth and extending over several square miles. The insects suddenly descended like a cloudburst, and whilst resting, devoured all the grass, fruits and leaves, as well as the slender striplings. Even the reeds, with which the huts were covered, although dry, were not spared.

Barrow, in relating his experiences in South Africa, mentions that on one occasion a district ten miles wide on either side of the Senegal River for a distance of eighty or ninety miles, that is, an area of about 1,600 to 1,800 square miles, was covered with locusts. Those that happened to be in the river at the time were there to such number that they almost blotted out the appearance of water. The insects devoured every blade

of grass and every plant in that region. Their departure from that place was also noteworthy. The mature locusts flew into the air but were driven into the sea by the wind. Their remains were later thrown on the shore and for about fifty miles they formed a mound about three feet in height. The immature forms journeyed northward and passed the dwelling place of two men belonging to Barrow's party. The procession past the house continued for over a month without interruption.

An Englishman happened to acquire a splendid tobacco plantation at Conohos in South America. He had heard that swarms of locusts frequently visited that locality, and so he caused all the tobacco plants to be placed nearer his house for better protection. The plants, about 40,000 in number, thrived and had reached a good size, when one day the cry was heard that locusts were approaching. The owner went out of his house and found himself in a thick cloud, that descended round about him. The cloud—a swarm of locusts—concentrated over the tobacco field and before long they attacked the plants. After a short time, the swarm rose and continued its flight. As a result of their activities, not one

tobacco plant remained and the field appeared to have been swept clean by a broom.

Great harm was done by locusts in Galicia, in 1828. The environs of Brzeganer had not been visited by locusts in forty-five years. Then the news came that great hordes were approaching Galicia by way of Odessa. They crossed the border line about the beginning of August. The people endeavored to save the harvest, but time was wanting, so that a good portion could not be gathered in. This was devoured down to the roots.

The swarm reached Brzeganer on August 26th. By shouts and noises and firing off of mortars the inhabitants tried to drive them away as they approached. It proved successful with regard to the first group that arrived around ten o'clock in the morning. A second array over four miles in width appeared north of Brzeganer at eleven o'clock. The inhabitants became worried about their own plantations, and as they gradually withdrew to their fields and gardens, the noise, shouting and shooting grew weaker. The entire swarm of locusts, not greatly frightened, alighted on the forest and neighboring fields to the north. Between twelve and one o'clock the main group of

insects arrived. When still over a mile away the crackling sound, like that of a forest during a storm, became audible. At one o'clock, the city and the horizon were in darkness, and excepting a few short intervals, the phenomenon perdured about six hours. The swarm extended between 30 and 40 miles in width and devastated the entire region. However, they met their fate at Brzeganer. The locusts remained about six weeks, but the rainy conditions gradually destroyed them. The remains were so numerous that on one day the inhabitants buried over 1,900 bushels and yet there appeared to be no appreciable decrease in the amount.

Swarms and ravages of like nature have been recorded in the writings of the Greeks and Romans. Pausanias, a Greek author of the first century of our era, states that outside the temple at Athens there stood a bronze statue of Apollo, ascribed to Phidias. This Apollo was called "Parnobion," because he set to flight the "Parnobes," or locusts. Pausanias also writes that he himself knows that locusts were destroyed on Mt. Sipylus on three occasions: once by a violent wind, then by noxious vapors caused by excessive heat immediately following a rainfall, and again by sudden coldness.

Pliny, the Roman naturalist (A. D. 23–71), records that at one time a great swarm of locusts came over the Sea from Africa, so that the Romans were frightened and consulted the Sibylline Books—a procedure only resorted to when the city was in danger and no means of defense known. At another time a swarm coming from Africa was driven into the ocean by the wind. The waters threw the dead locusts on the shores of Cyrene and their putrefaction caused vapors to poison the atmosphere, so that 80,000 persons died from disease.

In Cyrene, there was an ordinance requiring that the locusts be destroyed three times a year: by crushing the eggs, later by annihilating the immature forms that appeared, and finally, by killing the mature insects which had escaped detection. Any one disregarding this regulation was considered the same as a deserter and dealt with accordingly. On the Island of Lemnos it was officially prescribed how many locusts each inhabitant was obliged to kill and deliver to the proper authorities as proof of his endeavors.

Evidence is also available to show that these migratory creatures can travel great distances. The ocean often proves to be a source of destruction, especially if they encounter contrary winds.

However, they have been known to traverse seas of considerable width. They have even travelled from the mainland of Europe to the Balearic Islands.

On Nov. 21st, 1811, the ship Georgia, while sailing from Lisbon to Cuba, happened to be two hundred miles from the Canary Islands, the nearest land. At the time, a light southeast wind was blowing. Suddenly there was a calm and then a mild breeze came from the northeast. At the same time, a swarm of locusts appeared and alighted on the ship. They covered the decks, masts and all parts that gave a foothold. Yet, they did not seem fatigued after their long journey, because, when the men tried to drive them away they jumped from place to place and sought to evade the pursuers. The breeze lasted for about an hour, during which time more and more locusts descended.

On November 2nd, 1865, a sailing vessel was proceeding from Bordeaux to Boston. When 1,200 miles fom the nearest land, the ship was invaded by a swarm of locusts. They remained on and about the ship for two days and then departed.

Sir Hans Sloane, in the "History of Jamaica" (1649), relates that locusts had devastated the

Island of Teneriffe. They were seen to come from Africa and were carried along by the wind. They flew as far as they could, then alighted on the waters, one on the other, and formed an immense mass. Being refreshed by the sun the next day, they took flight again and landed in clouds at Teneriffe.

What Barrow remarks concerning the migrations of immature locusts, finds its parallel in other accounts. Hastings' "Dictionary of the Bible" says that in the East the undeveloped creatures spread like a pall over the land, eating everything green, and even stripping the bark off the trees. In order to arrest the march of the devastators, the natives dig trenches along the line of march, and when these are full of locusts, they turn back the soil to bury them, or direct water into the excavations to drown them. At times they also kindle fires in their pathway and drive them into the flames.

In "Locusts and Locust Birds in South Africa," Mrs. Barber mentions that these insects manifest the gregarious and migratory instinct when quite young and travel along on foot. After hatching, various groups unite, so that great numbers are present in a swarm. They lay waste a neighborhood and then travel onward to fields of fresh

crops. These immature forms make use of the roads and often travel a good many miles a day. Their progress is made by short leaps that are rapidly repeated. Such swarms travel northwards to the home of their progenitors, and no obstacles can arrest their march.

In the year 1871, a swarm attempted to cross the somewhat swollen Vaal River. The young locusts travelled back and forth along the river for several days, seeking a suitable place for traversing. Finally they returned to a bend in the river, where rocks were cropping out, and they plunged into the stream in vast numbers. A favorable current as well as the sedges and water plants growing on the rocks, were of great assistance, and thus they made a successful crossing.

Locusts have also attempted to cross the Orange River in Africa when it was several hundred yards in width. Great numbers plunged into the flooded stream until they became heaped upon each other in large masses. Groups of them were swept from the banks by strong currents, and as they grasped each other tightly and held together, they gave the appearance of floating islands. The individuals continually hopped and crept over each other as they drifted away. Whether they reached the other shore is not known.

These insects are not rapid swimmers, but when found in the water in great masses they do not easily perish. In their struggle, they are continually changing places by hopping and creeping round and round upon each other. It is known that they are exceedingly tenacious of life and have the ability to remain under water for a considerable time without suffering injury. A locust may appear drowned, but the warm rays of the sun will revive it, especially if it should be able to reach the bank of a river, or is cast ashore.

On one occasion, as Mrs. Barber relates, the undeveloped creatures met with a disaster. They had leaped into a stream from a steep sandy bank, only to find another similar straight wall on the opposite side, which gave them no footing. All their attempts were nugatory and in the end they perished in the river. There they putrefied and poisoned the waters so as to cause the death of the fish, which then floated on the surface. The noxious vapours arising were so powerful, that they prevented everybody from approaching the river.

After having noted the characteristic traits of the locust, the reader might ask the question: Is there anything advantageous to be remarked concerning this insect? A few facts can be

brought in its favor but in the main it must be viewed in the light of the Biblical Writers and Prophets.

Travellers in Africa relate, that places covered with bushes, perennial plants, and hard and half-withered grass, have suffered devastation from migratory locusts. Later, new herbs, lilies, fresh grass, and new shoots of perennial plants appeared, so that the areas were transformed into good pastures for cattle.

The locust has been and is used as food. The edible species are enumerated in the Pentateuch, for as St. Jerome states: "The locust, because it leaps, was counted as a clean animal and was allowed by God to be eaten by the Israelites." The New Testament (Matth. iii, 4 and Mark i, 6) mentions that this was the food of St. John the Baptist in the Desert. "Because clouds of locusts are found thoughout the vast solitudes of the burning deserts, they are used as food, and this is what St. John the Baptist ate." (St. Jer.)

These insects were considered delicacies by the Assyrians, and even at the present day, in all the cities of Arabia they are exhibited for purchase in the booths and are to be seen arranged in strings. In preparing them for meals the head,

wings, and legs are removed, and the body is fried in samn or clarified butter. However, the Turk in Arabia, Egypt and Africa abhors them. In Syria only the poorest people employ them as food.

The Bedouins, excepting those around Mt. Sinai, gather these creatures in vast numbers. They scald them in salt water, dry them in the sun or roast them in oil or butter in iron vessels, strew flour over them, and then partake of what is for them a palatable preparation.

Sparrmann, a physician, travelled into Central Africa in 1775. He relates that the Hottentots were beside themselves with joy whenever the locusts arrived, even though they brought desolation to the land. For the locusts were used as food and the natives even prepared some kind of brown soup from the eggs. Another traveller, Jackson, who visited the Barbary Coast in 1779, says that everywhere locusts were offered to him as an appetizing and rare dish.

Strabo, the Greek traveller and writer, tells of a race in Africa that started fires in trenches and in the valleys whenever the locusts traversed that region. By means of the smoke issuing from these fires they stupefied the locusts and caused

them to fall to the earth. The natives would then collect them, crush them in salt water, and from the mixture prepare some sort of cake.

Herodotus narrates of the Nasomones, who were related to the Libyans, that they dry the locusts in the sun, then crush them, and, after pouring milk over the mash, enjoy the preparation.

Thus the locust has manifested the self-same characteristics from the days of yore, when the Chosen People were held in bondage in the Land of Egypt, down to this twentieth century. In olden times it proceeded in battle array and brought desolation to the land it visited. Its mighty hordes have invaded regions in modern times and caused hardships and misery to mankind. As one poet (Southey) writes:

> "Onward they come, a dark continuous cloud
> Of congregated myriads, numberless."

Its dense masses could shut out the light of the sun as told by the Prophet Joel, even as Major Moore experienced in Eastern India. Yet its destructive influence was felt only when it appeared in multitudes, showing that united effort gave it strength. For its feebleness and insignificance was observed in the past, when it

pleased the Almighty to send a powerful wind to drive it from the land, just as happened in modern times in sections of Africa. Peculiar stridulations, compared by the Holy Seer of the Old to the "noise of a flame of fire devouring the stubble," find their counterpart in the crackling sounds, "like the noise of a forest during a storm," heard by the inhabitants of Brzeganer. Or as Whitman says:

> "I hear the rustling pattering of locusts, as they strike
> The grain and grass with the showers of their terrible
> clouds."

At times human beings may stem the onslaught of this individual, but its name is "*arbeh,*" and even man's endeavors, may come to naught. Then he must acknowledge the wisdom and the providence of the God above, Who created both this insect and its parasitic enemies: Who has so arranged that when the locust appears in vast multitudes, the parasitic torturer also multiplies in order to bring about its downfall. In this way there is once more established an equilibrium in Nature.

CHAPTER XI

SALT OF THE EARTH

ONE of the many articles employed in the preparation and seasoning of our food and also an item important in the manufacture of chemicals salutary to mankind, is that known as ordinary table-salt. In spite of its importance and necessity there are probably but few who have ever considered the interesting facts that could be cited in its favor. As a condiment to food, salt has come into such general use among civilized nations as to be regarded as indispensable. A similar fact is noticed among various individuals of the animal kingdom. To them, salt is also beneficial and acts as an antiseptic and a preventative of intestinal disorders. Wild animals as well as domestic cattle feel its necessity. The latter may receive it in the form of brine or have it strewn on the hay they eat, but the former must seek it for themselves in Nature. The great herds of the North American bisons satisfied their natural craving for it by making long

journeys to "salt licks," usually places where saline springs rose to the surface of the ground. The bisons would lick the ground that was covered with the incrustations. At times such regions would give way under the weight of these "Rulers of the Plains," so that the animals were mired. Accordingly, one of the most remarkable areas in Boone County, Kentucky, has received the name "Big Bone Lick" on account of the many individuals that were entrapped there.

Among the ancient writings that make frequent mention of this product are the Holy Scriptures, especially of the Old Testament. The writer of the Book of Ecclesiasticus (xxxix, 31) considers it one of the main necessities of life. In the prophecy of Sophonias (ii, 9) and in I Maccabees (xi, 35) salt-pits are mentioned. Because the Jews supported Antiochus the Great against Ptolemy Philopater, they received as a reward, gifts for their sacrifices: wine, oil and 375 medimni of salt. The Book of Leviticus (ii, 13) prescribes: "Whatsoever thou offerest thou shalt season it with salt." The Prophet Ezechiel says: "And the priests shall put salt upon them," i. e. calf and ram for the sacrifices. (xliii, 34.)

Besides using it for food and the sacrifices, the Chosen People employed salt for other purposes.

Ezechiel (xvi, 4), mentions a religious rather than hygienic custom of rubbing new-born babes with salt. In the Mischna it is recorded that a grain of salt, placed in a hollow or decayed tooth, was considered a universal cure for toothache. Salt was also used for preserving fish and pickling olives, vegetables, etc. Although no reference to it is found in the Bible, a custom existing among modern Jews may probably have obtained in olden times, namely that of laying all meat in salt and thus draining it more thoroughly of its blood.

A symbolical significance of salt is found in both the Old and New Testaments. "To have eaten of his salt" and thus enjoyed a person's hospitality was regarded as a pledge of eternal friendship. Again, it was an emblem of the Covenant: "a covenant of salt" between God and His Chosen People. Our Lord makes use of the expression when He said to His disciples: "You are the salt of the earth." Among other things He signified that the disciples were emblems of wisdom. Just as salt seasons food and makes it savory, so does wisdom season the mind and make it wise. This was the mission of His elect. The Latins said of a foolish man that he was without salt or unsalted, and concerning this de-

fect the poet Catullus writes: "Not one grain of salt in so big a body!" Lastly, salt was a symbol of barrenness, desolation, and death. Since an excess of saltness in the ground produced sterility, or as a city when destroyed was sown with salt—a sign that it was never again to be restored—so the idea was used in the abstract. The Book of Judges relates that Abimilech destroyed Sichem and sowed salt over the ruins.

Other ancient writers have references to this important product. Homer in the Odyssey writes of inland peoples who have no knowledge of the sea, nor do they use salt. The Numidian nomads in the time of Sallust, just like certain modern Bedouins, did not season their food with this ingredient. In some parts of America and India, the inhabitants did not use salt until it was introduced by Europeans. In Central Africa, where the natives live on milk and raw meat, the saline quality of the food is not lost. Accordingly, the condiment was not needed to make the food pleasant and wholesome. In such places salt is a luxury and enjoyed only by the rich.

Wherever human beings partook of cereals, vegetables, and boiled meats, there salt proved to be of necessity. If it did not exist in their

own localities, they manufactured it in a crude manner, or else had it brought to them from the seacoast or from places where salt incrustations were to be found on the surface of the soil. Aristotle relates that the Umbrians produced some such condiment from the ashes of plants that contained salt qualities. Tacitus in his Annals mentions that the ancient Germans poured the water of a brackish stream over a fire of salty wood and employed the residue for flavoring purposes. The same is told by Pliny of the inhabitants of Spain and Gaul.

By some of the peoples of old salt was considered a gift of the gods. According to the Stagirite, the Chaonians of Epirus possessed in their country a spring that flowed into a stream destitute of fish. Although the fish were greatly sought and desired, nevertheless the Chaonians felt that the gods had amply rewarded them by giving the salt ingredients to the river. To the ancient Germans a salty soil was sacred and they chose it as the most fitting place to offer up prayers to the gods. Even the Greeks and Romans considered the gods as the givers of salt, and so we find Homer calling it "divine" and Pliny wrote that it was a "substance dear to the gods."

As time elapsed and the cities became more populated, so that local supplies of salt no longer sufficed, the various nations found it necessary to open trade routes and obtain this article from distant regions. In ancient times this trade was carried on extensively along the caravan routes of Syria, Palestine, and Northern Africa. Similar trade routes were established in Europe. One important road of commerce existed between the ports of Phoenicia through Palmyra to the Persian Gulf. The Phoenicians traded in salt, as well as, in that valued delicacy—salt fish. Herodotus mentions a caravan route that united the salt oases of the Libyan desert. The modern caravan trade of the Sahara largely consists in this product. The ancient commerce between the Aegean Sea and Southern Russia included this article from the salt-pans at the mouth of the Dnieper, and the fish coming from the same locality. In olden times there was also to be found a trade route, the Via Salaria or salt highway, which ran from Rome by way of Reate and Asculum to the modern Porto d'Oscoli on the Adriatic coast—a distance of about 151 miles. Portions of the road are quite well preserved and may be seen in the Apennines at the present time. Along this route, the Sabines shipped the prod-

ucts of the salt-pans of Ostia into their own country.

Bearing on this question is our modern word "salary," which comes from the Latin for "salt" and dates back to ancient Rome. At first the word meant an allowance of salt to the officers and men of the army. Later on the "salarium" denoted an allowance of money to buy salt, and in post-Augustan times, the term included any allowance, pension or stipend. In Abyssinia and other parts of Africa, cakes of salt were formerly used as money. The economic importance is also seen in the taxes on the article and in the government monopolies. In Palestine this government monopoly existed under the Seleucids, in Egypt the Ptolemies had control, and in Rome the rulers also exercised this right. In the East and in the certain countries of Europe heavy taxes are still levied and as a result the "salt" reaches the consumer in a very impure condition, being very often mixed with earth. This is a practice similar to that existing in certain sections of South America where cocoa is tainted with fireclay.

The manner of manufacturing salt has in general been the same since ancient times. The Phoenicians obtained it by the evaporation of sea-

water. The Jews procured it from pits dug into the sand or slime on the shore of the Dead Sea. Into these pits the salt-water was admitted and allowed to evaporate. Again, salt was obtained by mining it. According to Strabo, the great salt mines of Northern India were worked before the time of Alexander the Great. In Palestine the chief source of supply was and is found in the hill called Kashm Usdum, on the southwest shore of the Dead Sea. This is a cliff of almost solid rock-salt, some 30 to 60 feet high, and extending for a distance of about 7 miles along the shore of the lake. Salt can here be obtained for many generations to come.

In our own day this article of trade comes from sea-water or from inland salt lakes. The ocean carries an abundant supply of it in solution. It has been estimated according to standard measurements, that if the entire ocean were to dry up, the total amount of salt furnished would be about $4\frac{1}{2}$ million cubic miles, or, about $14\frac{1}{2}$ times the land of Europe now existing above the high-water mark. From this vast storehouse man obtains salt by means of evaporation, a process employed in countries that have a sea-board as well as a long and dry summer, as in Spain, Portugal, France, and Italy. A strip of land is

levelled off and even banked by means of clay. It is then divided into larger and smaller basins so arranged that water can flow slowly from one level to the other. The salt-water is first admitted into the larger receptacles and allowed to evaporate to a certain extent. Being somewhat concentrated, it enters the smaller basins, until in the final troughs it has become so saturated as to form a sediment. The deposit is brought together into small heaps and permitted to drain. Later, it is gathered into larger masses and further drainage continues until the sediment or salt has become quite pure. By means of wooden scrapers it is then collected and in many cases finds its way to the market in this state. In other localities, the product is first sent to refineries, where it is washed and dried by heat, or is dissolved in fresh water, boiled down and put into trade as a pure, sparkling commodity.

Salt is also obtained from inland salt lakes by the same process. Supplies of it come from the great salt lake of Sambur in Rajputana, India, from the waters of the Dead Sea, and from the Great Salt Lake of Utah in the United States. The Dead Sea or the Salt Sea, as it is known in the Biblical account, is an inland lake about 47 miles long and from 2¾ to 9 miles wide. It is

1,293 feet below the sea-level, the lowest body of water on the surface of the earth. Its waters come from the River Jordan, and to all appearances there is no outlet. Hence, the only mode of escaping is by evaporation, with the result that it contains an immense amount of saline material in solution. 100 pounds of water from the Dead Sea are said to yield 24½ pounds of salt, whereas the same amount of water from the Atlantic Ocean would give only 6 pounds. Similarly, the Great Salt Lake of Utah is rich in the saline ingredients. In fact it is 24% salt. The writer, while making observations there, noticed that the water, after being pumped and raised from the lake, is caused to flow along troughs and trenches, until it reaches the level places. These act as immense basins, and the shallow water evaporates readily. The sediment or salt is then amassed into extensive mounds, and when completely dried, is put aboard railroad cars and shipped.

Geologists tell us that inland salt lakes, like the Dead Sea, Lake Elton in Russia, the Caspian Sea, and the Great Salt Lake of Utah, were arms of the ocean in the far distant past, and that now they are but small concentrated portions, having no connecticn whatsoever with the

large bodies of the water. Upon investigation, it is seen that these lakes are the final basins to receive water from other sources and they alone are saline in character. Thus Lake Tahoe flows into Pyramid Lake, Nevada, and only the latter is salt. The Sea of Galillee is a fresh water lake and empties into the Dead Sea—a salt lake. Lake Utah is also a body of fresh water and it has its outlet into the Great Salt Lake. These final reservoirs are said to have received their first great supply of salt when they were connected with the ocean, but in the course of geological time, the land rose higher around them, bringing about isolation. Due to the evaporation they shrank to insignificant remnants and became highly concentrated. The rivers and other bodies of water that appeared in the regions later on, supplied these lakes with a certain amount of water and also with salt material that was procured from the soil, and thus the salinity was retained.

To illustrate the manner in which such a body of water may have come about, the Great Salt Lake will serve as an example. Scientists say, that it is a small remnant of an immense ancient lake, which they have for convenience called Lake Bonneville. To the North it was connected

with the Pacific Ocean. At its maximum, it was 1,000 feet deep and covered an area of about 17, 000 square miles. Terraces which marked the former levels of this great lake are seen from Salt Lake City and outlying districts and are several hundred feet above the level of the present shoreline. In pre-Glacial times it was a salt lake. However, great amounts of fresh water emptied into this lake from rivers and springs, so that from salt water it changed to fresh and the excess flowed over the banks and found an outlet into the Pacific. In time, an arid climate prevailed and this caused a rapid evaporation of the water. By shrinking, it reduced its area and carried with it the soluble salts of the larger lake. Of this immense lake, there now remains but a small body of water 2,400 square miles in area, with a maximum depth of only 50 feet. Since all rivers and lakes contain a small amount of salt, it means that the Great Salt Lake is still receiving an additional supply.

For comparison, another body of water may be mentioned, which according to geologists has changed from saline to fresh water and remained in that condition. This is Lake Champlain in the northern part of New York. At a period when the immense Ice Sheets were retreating in

North America and the Great Lakes were being formed, the northeastern coast along the Atlantic was low, so that the ocean spread over the St. Lawrence Valley, Lake Ontario, Lake Champlain, and the Hudson River. This caused the entire territory now known as New England to be one large island. The ocean carried many strange objects into the inundated areas, and these relics are still unearthed today. Among them are to be mentioned the shells of animals living in the ocean and even the skeletons of whales. One of these skeletons has been found in the Lake Champlain terrace and another in the Ottowa Valley. As time went on, the waters deposited an immense amount of sediment, which filled in the low places and also caused the ocean-waters to recede. The salt character of Lake Champlain gradually diminished, owing to the small amount of evaporation. However, the principal reason given is that fresh water has poured into the lake in such quantities as to prevent concentration, so that the excess volume overflowed and now finds an outlet into the St. Lawrence River.

A condition similar to that of Lake Champlain would also exist if in some manner the Black Sea were separated from the Mediter-

ranean, the Baltic from the Atlantic Ocean, or the Bay of San Francisco from the Pacific. The supply of fresh water brought from the land by the rivers would be so great as to overcome the loss by evaporation. The waters in such an event would rise until they found an outlet and in time they would be fresh in character. On the other hand, if Mediterranean Sea were ever to be cut off from the Ocean at the Straits of Gibraltar, it would not only remain a salt-water lake, but would gradually diminish in size and finally deposit salt, like the inland salt lakes mentioned above.

It has been stated that commercial salt was obtained from the Great Salt Range of India before the days of Alexander the Great, and that the Jews had recourse to the great supply found in the hill bordering on the Dead Sea. It was procured from the rock-salt in the earth by mining processes. It is remarkable that Nature has furnished an abundant supply of salt in rock-form in many parts of the world. The investigations of the geologists have made known the fact that rock salt is found in nearly all the stratified groups of rock upon this earth [1] and in some cases at a very great depth. The Great Salt Range

[1] See Geological time table on page 263

of the Punjab in India dates back to the Lower Silurian Period. In Northern New York, Michigan and Ontario, Canada, there are Upper Silurian deposits. The important salt-formations of England, France and Germany come from the Permian and Triassic. The most noted rock-salt of Spain belongs to the Cretaceous and Tertiary. The famous salt-beds of Wielizka near Cracow were deposited during the Pliocene.

From all these petrifactions, salt is obtained either by mining or by boring and bringing it to the surface in the form of brine. In several States of the Union, like New York, Kansas, and Louisiana, a process similar to that of coal mining is employed. But most of the American salt is obtained from brine. Here a bore is made through the earth down to the salt layers. This bore is lined with tubing and where the tube passes through the salt it is pierced with holes. A smaller tube is let down into the first and between the two there exists an appreciable space, into which fresh water is allowed to flow. The salt at great depths is thus dissolved and it rises to the surface in the form of brine through the inner tube. After evaporation there remains but the salt itself.

The conditions bringing about the formation of rock-salt are said to have been not unlike those that caused the inland salt lakes. There existed bodies of salt water, there was an arid climate of long duration, and, furthermore, all the moist winds were shut off by high lands. In the various geological eras mentioned above, arms of the sea were either partly or completely shut off from the ocean by land barriers. The evaporation of the water was great and concentration could not be prevented by waters of the rivers nor by quantities that perhaps flowed over the land barriers. Thus, the waters became saturated with salt and when the basins had completely dried up, only the deposit remained. If the barriers were not too high, a fresh supply of ocean water would be admitted, especially, at high-tide and in times of storms. This would account for the thicknesses of many layers of salt. Beds of salt from 40 to 80 feet in thickness imply the evaporation of 3,000 to 6,000 feet of normal sea-water.

Just as the Mississippi at the present time carries immense quantities of granulated rock to be deposited at its mouth, so in the past geological ages, streams and other bodies of water brought sediments with them and completely

covered the salt formations. In many regions the rock salt now lies at great depths and it is almost impossible to ascertain how extensive these layers may be. Knowledge can only be obtained by boring into the earth in different places. In Northern New York, for example, the salt beds occur at depths ranging from 800 to 3,000 feet. The farther south the borings have been made, the greater has been the depth of the rock salt. In Livingston and Wyoming Counties, New York, these beds exist between 1,000 to 2,500 feet below the surface and they have a thickness of 50 to 100 feet. Around Ithaca, New York, several layers of salt having a thickness of about 250 feet are found at depths between 1,900 and 3,130 feet in the earth.

Common salt is considered one of the indispensable articles for our diet, and Almighty God has made wonderful provision of it for His creatures. Throughout the ages of the past it has existed either in soluble or hardened form and man from antiquity to the present has been given power over it. "All the works of the Lord are good and he will furnish every work in due time. Now therefore with the whole heart and mouth praise ye Him and bless the name of the Lord." (Ecclesiasticus xxxix, 39).

THE END

GLOSSARY

abiogenesis, same as Spontaneous Generation or the theory that life can arise in some other manner than from previously existing life.

albumen, a life food-substance, as illustrated for example, in the white of an egg.

ampulla, small bladder-like organ.

animalculae, microscopic organisms commonly found in water or prepared fluids.

antennae, elongated appendages with sensory functions found on the head of certain animals; "feelers."

anthropomorphic, relating to the conception of Nature, animals and plants by analogy with man. The word commonly implies an unscientific use of such analogy.

Archean Complex, the oldest rock formation of the earth, usually found at very great depths.

calcified, made like stone, due to the presence of lime salts.

calcined, treated so as to be easily crumbled.

Caloptenus (Greek: *kalos*, beautiful, *petnos*, winged), a genus of locust.

carbohydrates, a group of compounds containing carbon combined with hydrogen and oxygen; starches and sugars are the best known examples.

cellulose, a material related to starch and forming the wall-membrane of many plant cells; cotton and some paper are almost pure cellulose.

chitin, a horny material forming the hard covering of insects, lobsters, etc.

Clavellina, a small animal having heart, respiratory apparatus and digestive organs and attached to an object by means of a footstalk.

cosmogony, an explanation or theory of the origin of the world or universe.

dilatation, act of expanding or swelling.

ecdysis, the process of shedding the skin; moulting.

fertilization, union of male and female reproductive elements.

geometric (moths), insects, which in caterpillar stage move along with a looping characteristic. Also called "measuring worms" and belong to the family *Geometridae* or "land measurers."

gills, thin organs used for breathing the air in water.

gregarious, congregating.

grub, equivalent to caterpillar-stage of an insect; the first stage after leaving the egg.

Ice Sheets, the immense glaciers of the Pleistocene, which covered extensive portions of North America. They came as far south as Illinois and Kentucky.

ichneumon fly (Greek: *ichneuo*, to hunt), an insect that goes in search of larvae, upon which it lays its eggs, so that the young will be provided with food.

impregnation, union of egg nuclei with sperm nuclei; fertilization.

integument, an outer protective covering.

larva, first stage of an insect after leaving the egg; caterpillar or grub.

mandibles, the jaw-like teeth of animals like insects, lobsters, etc.

meteoritic, pertaining to an object or mass similar to that occasionally falling to the earth from space.

moult, the process of casting off skin, hair or feathers; ecdysis.

nebula, a luminous cloud-like arrangement in the heavens, like a distant star-cluster.

nebular, referring to a nebula as above.

nectaries, organs or parts of a plant, that produce "honey."

Orion, one of the great clusters in the heavens, containing three bright stars in a row (Swordbelt) and a nebula.

ovary, an organ or part where seeds and eggs are formed.

oviposition, egg-laying process.

Pachytylus (Greek: *pachus*, thick; *tulos*, knob or knot), *Cineraseus*: ash, a species of ash-colored locust.

Pentateuch, name given to the first five books of the Bible.

Perseus, a constellation located in the Northern Sky.

pistil, part of a flower containing the female reproductive organ and later holding the seed.

planetesimals, minute particles that are supposed to have moved nearly independently like planets.

polarity, quality whereby the properties of a mass are attracted to one pole and repelled from the other.

pollen, the fine powder produced by flowers.

pollination, the process whereby pollen or the male reproductive element in plants is brought to the female portion.

psyche, the soul.

Schistocerca (Greek: *schistos*, cloven; *kerkos*, tail), a genus of locust.

Sipylus, Mt., a mountain near Smyrna.

spheroids, bodies having almost the form of a ball or globe.

Spiral Nebula, a cloud-like object in the heavens, which winds or circles round a centre and gradually recedes from it in streams.

Stagirite, a title given to Aristotle, who was born in the Macedonian town, Stageira.

stamens, modified leaves of a flower that contain pollen.
stigma, the roughened or sticky surface at the end of a pistil which receives the pollen.
stridulations, shrill, creaking sounds made by certain insects.
tibia, the portion of the leg between the thigh and "ankle"; enlarged in locusts.
turgid, unnaturally swollen, due to the pressure of liquids within the cells of plants.
viscera, organs in the abdominal cavity. The term is also used to signify the intestines.

Division of Time and Rock-formation According to Geologists

ERAS AND GROUPS	PERIODS AND SYSTEMS	EPOCHS AND SERIES
Cenozic (Recent life)	*Quaternary*	*Recent* *Pleistocene*—time of the great glaciers.
	Tertiary	*Pliocene*—Skeletal remains of the camel in the rocks, show that it once lived in North America. The camels are said to have attained a larger size than any existing species. Evidence seems to show that Japan was colder during this time than in the Pleistocene. *Miocene*—The valuable phosphate deposits of Florida, the oil of Louisiana and the diatomaceous earth of the Atlantic coast, come from this epoch. The diatomaceous earth is used in manufacturing preparations for polishing silver, nickel, etc. In this epoch the rhinoceros lived in North America. *Oligocene*—Workable lignite beds in Germany, Switzerland and southern France are found in this series of rock. Around Paris are found Oligocene salt deposits. *Eocene*—The ancestor of the modern horse—no larger than a sheep—is supposed to have lived at this time.

PERIODS AND SYSTEMS

Cretaceous—"Age of Chalk." The Cretaceous system of rocks is prominent in northwestern Europe and consists of a thick mass of white chalk. The Cretaceous rocks are also rich in organic remains.

Mesozoic (Middle life)

Jurassic—named after the important rock-formations in the Jura Mountains. Among the animal-remains of this period found in the United States is the Atlantosaurus, supposed to have been 100 feet long and 30 or more feet in height. The Petrified Forests near Adamana, Arizona, are said to date back to this time.

Triassic—named after the three well-marked series of rocks found especially in northern Germany. Various footprints in Triassic sandstone point to the presence of the dinosaurs ("terrible reptiles"). The footprints are found in great abundance in the Connecticut Valley.

Permian—named after a district in Russia. During this period the thickest known salt deposits were accumulated; one formation near Berlin has been penetrated 4,000 feet.

Carboniferous—The greatest coal deposits now found in England, France, Germany and the United States come from this period. There was an abundance and variety of vegetation.

Devonian—named after Devonshire England, where the "Old Red Sandstone" is prominent. The important oil and gas-bearing strata of West Virginia, Pennsylvania and southwestern New York are found in Devonian rock. This period has also been called the "Age of Fishes."

Paleozoic (Ancient life)

Silurian—The name is given to a series of rocks found in England and Wales where formerly lived the ancient tribe of the Silures. Silurian rocks are also found in the northeastern Atlantic States and in the Mississippi Valley.

Ordovician—named after the Ordovici, an ancient British tribe. The marble coming from Vermont and Massachusetts is Ordovician. Some remains of fishes have been discovered in Ordovician rock of Wyoming and Colorado.

Cambrian—derived from Cambria, the ancient name for North Wales. The rocks found there are equivalent to those of the Potsdam limestones of New York and they contain among other animal-remains: sponges, corals and tracks of worms.

GEOLOGICAL TIME TABLE

ERAS AND GROUPS

Pre-Cambrian—The rocks comprise the Archean Complex. It is a series of crystalline layers and massive rocks that lie underneath the most ancient fossil-bearing formations. The series is also called *Azoic*, because thus far no traces of life have been found in them. A very good example is found in the Grand Canyon of Arizona. At a depth of 6,000 feet below the rim, where the Colorado River flows, the writer saw walls of gneiss and granite said to be part of the original crust of the earth. This is the oldest rock known to geologists.

The above table has been arranged so that the most ancient times are at the bottom and the latest at the top. Nothing definite is known concerning the age of the Pre-Cambrian rocks. The Sacred Writings simply tell us that "in the beginning God created heaven and earth." Likewise "So the heavens and earth were finished and all the furniture of them." (Genesis). Hence the age of the earth is a matter of speculation. The manner of determining this age is by observing the rate with which material is deposited or accumulated by rivers, streams, etc. (e.g. the Mississippi) as well as the rate of erosion or wearing away of rocks and earth by weather conditions, water, etc. as may be seen at Niagara Falls. Scientists differ in their calculations but according to Dana's *Manual of Geology* "the safe conclusion from all geological and physical facts is that Time is long, very long; long enough for the development of all the earth's rocks, mountains, continents and life."

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